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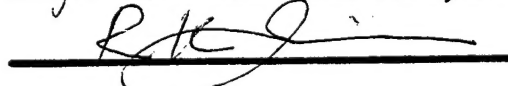
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FOR TITLE III OF THE
1990 CLEAN AIR ACT AMENDMENTS

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Abstract

This dissertation presents the development of an alternate compliance strategy (ACS) incorporating pollution prevention and flexibility to replace traditional end-of-pipe control strategy. The ACS was based on the Hazardous Organic National Emission Standards for Hazardous Air Pollutants (HON) rule which is the first major Title III regulation under the 1990 Clean Air Act Amendments (CAAA).

The ACS is defined by converting language in the HON rule into a performance based standard permitting regulated facilities to design compliance programs to meet the required hazardous air pollutant (HAP) emission reduction. The ACS can be used to meet all other HON regulation requirements.

Three evaluation methods are developed to compare the ACS to the compliance methods in the HON rule. The first evaluation method, an Evaluation Matrix, is qualitative, relying on twelve criteria selected from comments of interested parties. The second method incorporates the EPA's Total Cost Assessment program; a comprehensive, long-term financial analysis method of pollution prevention projects and other options. The third evaluation method estimates the magnitude change in risk from changes in the quantities and/or types of HAPs released. This method, based on risk assessment and engineering principles, provides a method of insuring pollution prevention compliance programs are as protective of human health and the environment as traditional end-of-pipe control technology.

An example facility was characterized using information from engineering references and a Dow Chemical ethylene oxide, ethylene glycol plant. The ACS and the reference control technology (RCT) compliance programs were applied to the HAP emissions at the example facility. The ACS reduced HAP emissions more than the RCT compliance programs and met all other HON requirements.

The three evaluation methods were used to compare the compliance programs developed for the example facility. The scoring in the Evaluation Matrix suggested the ACS was the preferable compliance method. The Total Cost Assessment indicated the ACS program was the preferred investment, by a small margin. The Risk Reduction Measurement Model demonstrated the ACS compliance program reduced risk by a greater amount than the RCT program.

The ACS should be incorporated into the HON rule and other similar Title III regulations as an alternative method of compliance. The basic concepts of ACS can be incorporated into other 1990 CAAA and other media regulations. The ACS provides a major step in the progression of moving regulations from the traditional end-of-pipe treatment philosophy to pollution prevention performance based standards.

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AN ALTERNATE COMPLIANCE STRATEGY
FOR TITLE III OF THE
1990 CLEAN AIR ACT AMENDMENTS

I. Introduction

Since its inception in 1970, the United States Environmental Protection Agency (EPA) has developed, promulgated, and enforced an expansive array of environmental regulations. This effort continues yet today in response to Congressional mandate. The developed regulations have become progressively more expansive, more stringent (lower levels of emissions allowed), and more costly to the regulated community. In addition, the individual regulations are becoming more prescriptive and detailed in nature, specifying exact methods, equipment, and records necessary for compliance with environmental requirements.

In the past decade, benefits have been realized in moving past historic pollution management or end-of-pipe control technology to pollution prevention. However, the EPA has been slow to incorporate pollution prevention concepts and other innovative ideas into its regulatory process. An example is the Title III, Hazardous Air Pollutants, regulations of the 1990 Clean Air Act Amendments (CAAA) currently being developed and promulgated.

In April 1994, the EPA published the first major Title III regulation, entitled the Hazardous Organic National Emission Standards for Hazardous Air Pollutants (HON) or the Chemical Manufacturers rule.¹ The HON regulation relies on a reference control technology (RCT), which is a new name for the end-of-pipe control compliance philosophy. Although the new regulation includes some pollution prevention provisions, it does not go far enough in adopting the pollution prevention ethic as a compliance tool.

The goal of this research is to develop and demonstrate an alternate compliance strategy (ACS) that incorporates pollution prevention and flexibility, while encouraging innovative technology. The alternate compliance strategy meets all required emission reductions and is applicable to other Titles of the 1990 CAAA as well as other regulatory programs such as the Clean Water Act.

Background information is provided on pollution prevention, the CAAA, and limitations of current regulations. The pollution prevention discussion explains the EPA program, discusses its future and describes why it has been so difficult to incorporate pollution prevention in the regulatory format. The CAAA summary focuses on the HON rule because it is an ideal example for developing the alternative compliance strategy. The history of hazardous air pollutants regulation, pertinent portions of the HON rule, and the comments on the HON rule are summarized. The comments are important in evaluating the concerns various interested parties had about the HON regulation. In addition, various reports and recommendations for improving regulations have been reviewed and are presented.

The alternate compliance strategy is defined using existing portions of the HON rule. It relies on a performance standard in the HON rule and contains special provisions for encouraging pollution prevention and broad compliance programs. The strategy allows a regulated facility to calculate its allowed HAP emission rate and design a compliance program to meet the required reductions. All other provisions of the HON rule, i.e. monitoring, performance testing, and recordkeeping, must be met as defined in the rule.

Methods were needed for evaluating the alternative compliance strategy and comparing to existing compliance methods in the HON rule. Three evaluation methods are developed: (1) Evaluation Matrix, (2) Total Cost Assessment Model, and (3) Risk Reduction Measurement Model.

The Evaluation Matrix contains twelve criteria important in regulation appraisal. The criteria are developed from the comments on the HON rule and from an analysis of the EPA development of the HON rule. The Total Cost Assessment Model is adapted from an existing economic/financial analysis method designed to evaluate pollution prevention projects and other more traditional projects. The Risk Reduction Measurement Model is developed from basic risk assessment concepts to evaluate the magnitude of the change in risk between different air pollution emission reduction programs.

An example facility is characterized for application and evaluation of the alternate compliance strategy. The example facility is developed using information from a Dow Chemical Company Glycol II plant and EPA documents. Compliance programs are developed for the facility using both the end-of-pipe treatment requirements of the HON rule and the alternate compliance strategy. Finally, the compliance programs as applied to the example facility are compared using the three evaluation methods listed above.

Development and application of the alternate compliance strategy demonstrates pollution prevention can be incorporated into Title III regulation. The alternate compliance strategy compliance program developed for the example facility demonstrates that pollution prevention compliance programs can not only meet the same emissions reductions of end-of-pipe treatment but also go beyond. The alternate compliance strategy can meet the same regulatory requirements, meet basic criteria of interested parties, be implemented at a comparable cost, and reduce risk more than traditional forms of compliance. This research establishes the next logical step in environmental regulation as the country moves from end-of-pipe to pollution prevention.

II. Pollution Prevention

2.1 Introduction

Pollution prevention is the new direction in environmental management. It emphasizes reducing pollution by implementing cleaner technologies, using less toxic materials, and by reducing pollution at the source instead of controlling the pollution after it is generated.

This chapter is divided into four sections. Section 2.2 provides a summary of the nation's pollution prevention program, including a discussion of two milestones, the Superfund's Toxic Release Inventory requirement and the Pollution Prevention Act. In Section 2.3, specific EPA pollution prevention programs are discussed and in Section 2.4, the potential future role of the EPA in implementing pollution prevention is discussed. Section 2.5 summarizes the difficulties and impediments encountered in implementing pollution prevention programs.

2.2 The Pollution Prevention Program

In the last two decades, the nation has responded to its pollution problems in an evolutionary manner. Initially, the need for pollution control was recognized and implemented in a broad spectrum of programs and regulations. Then the nation moved toward waste management and waste minimization and ultimately pollution prevention.² Industry contends some pollution prevention has been practiced for as long as there has been manufacturing, under the name of yield improvement.³ The EPA's focus and program development can be tracked by their brochures: the Waste Minimization Opportunity Assessment Manual printed July 1988,⁴ and the Facility Pollution Prevention Guide printed May 1992.⁵

A strong pollution prevention motivator for industry was the Superfund's Toxics Release Inventory which followed the catastrophic accident in Bhopal, India. The Toxics Release Inventory program requires industry to estimate and publicly announce toxic emissions, chemical

by chemical and facility by facility. Prior to this regulation, industry had never been required to report these types of releases. When the first inventory was released in 1987, corporate management and the public were shocked by the billions of pounds of toxic pollutants that were being emitted. Corporate management recognized the lost resources escaping up stacks and out the pipes, and the enormity of the hazardous waste issue. The public, concerned for their own safety, provided considerable impetus to the corporations to reduce toxic emissions.

An additional motivator, particularly for the agencies involved in regulating pollution, is the realization of the limitations of pollution control programs. Although the prescriptive command and control approach of controlling pollution has been successful in reducing flagrant pollution, it has a major drawback of shifting pollution from one media to another.^{1, 2} Technology-based regulations have not resolved difficult, complex issues like acid rain, global warming and a thinning stratospheric ozone layer. And it is recognized by the EPA, these regulations may be counterproductive by inhibiting innovation and discouraging regulated industries from going beyond the minimum legal requirements.

A landmark in the pollution prevention program was the passage of the Pollution Prevention Act (PPA) of 1990. With this Act, Congress declared pollution prevention to be the national policy of the United States. Specific provisions of the PPA required the EPA to establish a source reduction program and provide information and technical assistance to States on source reduction.⁶ The EPA has used the act to reinforce its Environmental Management Options Hierarchy. The hierarchy of pollution management, in order of preference, is source reduction, recycling, treatment, and disposal. The EPA defines pollution prevention as the first two categories: source reduction and closed loop recycling.

There are two general methods of source reduction: product and process changes. Product changes include designing products for less environmental impact and/or increasing the product life. Process changes include input material changes for reduced toxicity, technology

changes to reduce pollution volume, and improved operating practices for cleaner operations. Recycling includes reuse (closed-loop recycling) and reclamation. Off-site recycling (the waste is moved to a different facility for processing) is considered treatment.⁵

The EPA encourages industry, utilities, government, and other waste generators to adopt a pollution prevention program. Cited benefits include: reduced risk of liability, reduced operating costs, improved company image, and increased public health and environmental benefits. A recent report completed by the Office of Technology Assessment, U.S. Congress stated,

"End-of-pipe methods often result in increased costs with no appreciable benefits to the firm in the form of enhanced materials or energy efficiency. In contrast, pollution prevention and recycling investments often not only lower energy and material usage but also reduce end-of-pipe treatment costs, resulting in decreased disposal expenditures, possible reduced paperwork, and lower liability and insurance costs."⁷

Pollution prevention programs require planning, funding and participation from all levels of an organization. The main steps are:

1. Establish the pollution prevention program
2. Organize program
3. Do preliminary assessment
4. Write program plan
5. Conduct detailed assessment
6. Define pollution prevention options
7. Conduct feasibility analyses
8. Write assessment report
9. Implement plan
10. Measure progress
11. Maintain pollution prevention program⁵

Many waste generators have pollution prevention programs and have significantly reduced their pollution levels in the past several years. Considerable research has been conducted by the EPA and other organizations to develop source reduction methods for different source categories.^{8,9}

2.3 EPA Programs

The EPA has developed numerous programs to promote pollution prevention. The programs range from extensive training for regulatory personnel at all levels of government, training programs for industry personnel, numerous brochures, and research programs, to a computerized data clearinghouse. Five of the programs that relate to this research will be discussed.

The Source Reduction Review Project (SRRP) has been developed to incorporate source reduction measures and multi-media issues within future air, water, and hazardous waste standards. In the short term, 17 industrial categories are under evaluation and for the long term, different approaches are being evaluated to provide a model for the regulatory development process throughout the EPA.⁸

Another EPA pollution reduction program, the 33/50 Program is a voluntary program to reduce toxic waste from industrial sources. EPA targeted 17 toxic chemicals for reductions of 33 percent and 50 percent by the end of 1992 and 1995, respectively. Over 1000 companies have committed to participate.

The Pollution-Prevention Information Clearinghouse (PPIC) is an information repository maintained by the EPA for the public and industry to provide information on methods, processes, and technologies for pollution prevention. The PPIC maintains a large collection of documents, a computerized public forum, and a data base system called the Pollution Prevention Information Exchange System.

The Clean Technologies Program is one of EPA's many research programs. This program focuses on the development and application of innovative pollution prevention methods and clean technologies. Accomplishments include developing a wide range of technical documents on pollution prevention and clean technologies, and conducting numerous pollution prevention opportunity assessments at industrial sites.¹⁰

A different type of program is Total Cost Assessment, a comprehensive, long-term financial analysis of pollution prevention projects and other, more traditional projects. This financial analysis procedure provides a more precise estimation of the real economic returns to projects than the typical costs of projects. Total Cost Assessment includes full accounting for less tangible, longer term, and indirect costs and savings. For example, this analysis can include estimates for reduced operating costs from reduced waste generation, reduced cost from regulatory requirements and decreased pollution related liabilities, both real and potential.¹¹

2.4 EPA's Future Direction

The EPA's directive of assimilating pollution prevention into its operations has even come from the president. Recently, President Clinton and Vice President Gore endorsed a program entitled "Technology for a Sustainable Future, A Framework for Action".¹² As part of the program, the President states "the Administration ... will seek ways to spur the development of a new generation of technologies that prevent pollution". The four major dimensions of development and diffusion of technology in the booklet are:

- * Facilitating Innovation
- * Encouraging New Approaches
- * Engaging the World, and
- * Learning and Working Together.

The new EPA Administrator, Carol Browner stated the EPA has taken significant steps in reflecting its pollution prevention commitment. Two examples include the EPA's budget request for a \$33 million increase for pollution prevention spending in 1994 and the Executive Order signed by the President on Earth Day 1993 establishing voluntary source reduction goals and reporting requirements for toxic chemicals for federal agencies. Ms Browner stated, these accomplishments "are only the starting point. We must go further by integrating pollution

prevention into all of EPA's traditional activities." Some of her ideas for doing this include more innovative use of traditional tools like regulations and providing the regulated community with greater certainty and incentives to develop multi-media compliance strategies. She concluded the article with, the EPA's transition to the new environment ethic of pollution prevention "will succeed only if we are willing to question established practices, cooperate across program and agency boundaries, and not hesitate to acknowledge shortcomings as well as success stories."¹³

In April 1994, Michael Stahl, the Deputy Assistant Administrator, Office of Enforcement and Compliance Assurance, EPA, presented a paper entitled "New Directions for Enforcement: New Opportunities for Pollution Prevention". During the presentation to the National Roundtable of State Pollution Prevention Programs, he discussed the reorganization of the EPA and the strong commitment the EPA has made to establishing pollution prevention as a principal means of environmental protection.¹⁴

2.5 Difficulty in Implementation

For all the advantages of pollution prevention, it is considerably more difficult to implement than end-of-pipe control programs.⁷ End-of-pipe control is usually a device placed at the end of a process, whereas a pollution prevention project implemented on the same process is typically more encompassing. Pollution prevention projects require modifying procedures and equipment within the process itself. Pollution prevention projects can be facility and product specific, therefore not easily transferred to another facility or product. Often these projects encompass different phases of a process or product's manufacture or even several different processes and products. Effective pollution prevention projects often involve everyone from the least skilled worker, to the most skilled worker, the plant engineer, and the top manager.

The EPA and other regulatory agencies have similar difficulties with pollution prevention. Pollution prevention is more difficult to write into regulations and enforce afterward, partially

because programs must be somewhat site specific and evaluation is more subjective. A pollution baseline must be determined for a particular site and improvements must be measured against this baseline for all pollution prevention actions implemented. The regulatory personnel must also have greater depth and breadth of knowledge of an industry to effectively evaluate pollution prevention projects. It is much simpler to look at a pollution control device and determine if it is working properly than to evaluate a new complex pollution prevention project.

The sociology of the workplace can generate obstacles to pollution prevention projects. Three important aspects of an organization - its culture, its ability to process information, and its politics - can affect whether a pollution prevention project is implemented. The critical decision making stages of a pollution prevention project are identifying the opportunity, finding an appropriate solution, and implementing. If the culture of the facility limits interactions between different types of employees, many pollution prevention projects will be overlooked or not implemented. Information processing may also limit pollution prevention projects because implementation requires people to understand more than the intimate details of the production process; they must also understand the technical possibilities. Finally, resources like capital and people are allocated by intensely political or competitive processes. Unless the true costs and potential profitability of pollution prevention options are well documented, other more traditional projects will receive limited company resources.¹⁵

A major limiting factor in promoting pollution prevention is the limited useful and consistent data on the extent and the effect of pollution prevention programs. This is especially true for technologies that prevent generation of multi-media releases. This lack of data limits the ability of the industries to justify new pollution prevention projects and substantiate the emission reduction to the EPA. In turn, the EPA has difficulty documenting the nation-wide effectiveness of the pollution prevention program because of the lack of data. Five reasons for the lack of reliable data are summarized below:

1. Source reduction data can be hard to quantify, because when the waste stops being generated, it can no longer be directly measured.
2. It is simpler to quantify pollution prevention progress with a facility manufacturing a single product, than with a multi-product facility with combined waste streams. Unfortunately, most waste generators are multi-product facilities which make hundreds of products and may or may not combine the waste streams.
3. Most completed pollution prevention projects are not well documented. Often pollution prevention projects were a part of a much larger project and never singled out for documentation, or at the other extreme, implemented by workers who did not document the project.
4. Pollution prevention data required by the EPA for compliance with the Resource Conservation and Recovery Act (RCRA) and the Superfund Amendment and Reauthorization Act (SARA) is inconsistent and each law uses different definitions. Also the data format required by these laws is impractical for multi-product manufacturing facilities with combined waste streams.
5. Pollution prevention data collection has been difficult because the collection forms are intimidating, complex, and ask for data not readily available and of questionable value. The problem can be stated "...the reliability of the responses to a questionnaire decreases, as the complexity of the form increases."¹⁶

III. Clean Air Act Amendments Summary

3.1 Introduction

The monumental task of assuring the air breathed in the United States is free from harmful contaminants falls to a regulatory program initiated in 1955 with the Air Pollution Control Act. Since then, five acts have been passed, each increasing the scope, complexity and thoroughness of legislation and subsequent regulation in an attempt to meet the original goal of clean air.

The Clean Air Act Amendments (CAAA) of 1990, signed into law on November 15, 1990 by President Bush, will have a sweeping impact on the way air pollution is evaluated and controlled in the United States.¹⁷ The amendments are expected to affect the fuel for vehicles, the amount of pollution industries release, the level of acid rain, depletion of ozone in the upper atmosphere, and numerous other air pollution problems, all at a substantial cost. The CAAA contains eleven separate, complex titles covering different regulatory programs, with a total length of over 1000 pages. This project is focused on Title III - Hazardous Air Pollutants or Air Toxics as it is commonly called.

This chapter, an overview of relevant portions of air pollution regulation, is divided into five sections. Section 3.2 provides a summary of the EPA's efforts and problems encountered, since 1970, in trying to develop the National Emission Standards for Hazardous Air Pollutants. Section 3.3 briefly summarizes the 11 titles of the 1990 Clean Air Act Amendments and Section 3.4 provides additional background information on Title III. In Section 3.5, the HON regulation is introduced and Section 3.6 discusses the pollution prevention provisions incorporated within the HON regulation. Section 3.7 summarizes public comments on the HON rule with an emphasis on those relating to flexibility and pollution prevention issues.

3.2 Historic Hazardous Air Pollutants Regulation

The first regulation of hazardous air pollutants occurred under the Clean Air Act Amendments of 1970, section 112, and was subsequently amended in 1977. The 1970 Act required the EPA to develop National Emission Standards for Hazardous Air Pollutants (NESHAPs). The NESHAPs were to be developed for carcinogenic, mutagenic, and toxic air pollutants while providing an ample margin of safety to protect the public health. The standards for these chemicals recognized a need to regulate air pollutants which were different from the pollutants regulated under the National Ambient Air Quality Standards. Hazardous air pollutants were unique because of the nature of their toxic or hazardous properties and the localized contamination problems they posed. The eight hazardous chemicals regulated under the 1970 and 1977 amendments are listed in Table I.

In order for the EPA to develop these standards, risk assessments were required of each chemical to determine at what level, if any, these pollutants are safe. These risk assessments involved extensive information in the form of source data, atmospheric fate and dispersion models, and risk factors derived from health assessment studies.¹⁸ Because the statute language requires the EPA to base standards solely on human safety with no regard to cost or feasibility, EPA was placed in an impossible situation. Many of the hazardous air pollutants are carcinogens or suspected carcinogens, for which there is no safe level of exposure. If the EPA was to regulate these pollutants, then zero emission limitations would have been required to protect human health. This would have required closing much of the country's industry, including steel and electric power plants, which emit small quantities of toxic air pollutants.^{19,20}

The EPA attempted to implement the "ample margin of safety" criteria with a two-fold strategy. First, the EPA attempted to develop emission standards incorporating economic and technology factors. Second, a lengthy decision-making process was set up to "study" each pollutant before listing and adopting emission standards. During the late 1970s and early 1980s,

the EPA developed the concept of Best Available Technology (BAT) or Best Available Control Technology (BACT) Standards to be required for sources of regulated hazardous air pollutants. The standards relied on the most advanced control technology and incorporated economic and social issues. In 1985-1986, the EPA published BAT-based NESHAP standards for benzene, radionuclides, and vinyl chloride. In 1985, a court of appeals struck down use of the BAT standards by stating the EPA Administrator had failed to exercise discretion in determining an "acceptable risk to health," and had "simply substituted technological feasibility for health as the primary consideration." In 1989, the EPA again published NESHAPs for benzene and radionuclide sources using a maximum individual lifetime risk evaluation system.²¹

Because of the carcinogen dilemma, the extensive studies required and additional administrative requirements of the statute, the EPA listed only the few chemicals in Table I. Some of these chemicals took as much as four years from the time of publishing a decision on intent to list to actual listing and establishment of subsequent emission limits. Twenty one additional chemicals were proposed for listing in 1984 and 1985, but standards were never promulgated because of insufficient information and legal battles.

Table I. Hazardous Chemicals Regulated Under NESHAP

Pollutant	Date of Notice	Final Standard
Asbestos	1971	1973
Beryllium	1971	1973
Mercury	1971	1973
Vinyl chloride	1975	1986
Inorganic arsenic	1980	1986
Coke oven emissions	1984	1987
Benzene	1977	1989
Radionuclides	1979	1989

Source: ENSR, Dwyer

3.3 1990 Clean Air Act Amendments

The most recent legislation, the Clean Air Act Amendments, contains eleven separate, complex titles covering different regulatory programs with a total length of over 1000 pages. The titles are:

Title I. Air Pollution Prevention and Control, addresses the nonattainment of the National Ambient Air Quality Standards. This title requires tighter controls on industries and revised State Implementation Plans. Title I sets new deadlines for nonattainment areas to reach attainment and strict penalties if attainment is not reached.

Title II. Mobile Sources and Clean Fuels, requires further reductions in mobile source emissions. The title requires more stringent vehicle emission standards, sets up a clean-fueled vehicle program, and initiates a clean fuels program. Title II works together with Title I in ozone nonattainment areas.

Title III. Hazardous Air Pollutants, attacks the issue of air toxics by establishing a long list of hazardous air pollutants to be regulated and commands the EPA to impose strict, technology based standards. This title is discussed in greater detail in subsequent sections.

Title IV. Acid Deposition Control, establishes a new control scheme for addressing the acid rain problem. The title will affect major coal fired power plants and will require significant reductions in sulfur dioxide and nitrogen oxides over the next six years. The emissions reductions will be met through a new market-based system using allocated emission allowances.

Title V. Permits, requires nearly all sources of significant air emissions to apply for and obtain a permit. The title outlines basic provisions to be included in the permits.

Title VI. Stratospheric Ozone Protection, provides for a phase-out of production and sale of chlorofluorocarbons (CFCs) and several other chemicals thought to be destroying the stratospheric ozone layer. The title includes controls on various CFC-containing products.

Title VII. Enforcement Provisions, adds tough new enforcement authorities, including both civil and criminal sanctions. Civil enforcement contains provisions for administrative penalties, field citations, administrative orders, and citizen suits. Criminal sanctions can be filed for violations in general, recordkeeping crimes, negligent and knowing endangerment, presumption of violation, and bounty.²²

Title VIII. Miscellaneous Provisions, addresses visibility and emissions from sources on the Outer Continental Shelf, visibility transport regions, and sets up a Grand Canyon Visibility Transport Commission.

Title IX. Clean Air Research, requires air pollution research on monitoring and modeling, health effects, ecological effects, accidental releases, pollution prevention, emissions control, acid rain, and alternative motor vehicle fuels.

Title X. Disadvantaged Business Concerns, requires, to the extent practicable, not less than ten percent of the total Federal funding to be made available to disadvantaged business concerns.

Title XI. Clean Air Employment Transition Assistance, contains provisions for additional unemployment benefits for workers laid off because of compliance with the CAAA.²³

3.4 Hazardous Air Pollutants

In previous Clean Air legislation, the EPA had regulated eight hazardous air pollutants. In an attempt to extend the coverage of the air pollution protection program, Title III of the 1990 CAAA established a list of 189 toxic pollutants to be regulated. The EPA is required to impose tight controls on the 189 substances (assuming all are to be regulated) in accordance with a new two-phase strategy. The first phase is to be based on classic end-of-pipe technology standards and will require facilities to install the Maximum Achievable Control Technology (MACT). The second phase requires an evaluation of residual risk to insure public health is protected from the remaining pollutants after MACT is initiated.²²

The MACT requirements will be determined for source categories and subcategories of industries which emit substantial quantities of each hazardous air pollutant. The EPA developed and used the Source Category Ranking System (SCRS) to prioritize the categories for regulation. The SCRS combines emission estimates, health effects data, and limited population data to rank categories of sources. The EPA has published an initial list of source categories that warrant regulation.²⁴ The EPA has also published a draft schedule for the promulgation of the emission standards for the various categories of sources.²⁵ The EPA is required to promulgate regulations of approximately 200 source categories by the year 2000. A source category is defined as a group of similar industries that are known to generate significant quantities of hazardous air pollutants. Examples include: incinerators, lead smelters, steel plants, paper mills, and landfills.

MACT will be required of any source which emits 10 tons per year or more of an individual hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants. The EPA will promulgate the regulations such that:

"the maximum degree of reduction in emissions of the hazardous air pollutants subject to 112 (including a prohibition on such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for new and existing sources in the category or subcategory to which such emission standard applies."²⁶

"the maximum degree of reduction in emissions that is deemed achievable shall be subject to a floor which is determined differently for new and existing sources. For new sources the standards set shall not be any less stringent than the emission control that is achieved in practice by the best controlled similar source. For existing sources, the standards may not be less stringent than the average emission limitation achieved by the best performing 12 percent of existing sources in each category or sub category of 30 or more sources."²⁶

It is expected that the MACT standards will require emission reductions of approximately 75% to 90% below current levels. The primary EPA consideration in establishing MACT standards must be demonstrated technology. The new standards may include measures to require process changes, substitution of materials, system enclosure, pollution control devices, and operator certification and/or training. Other considerations include: cost, energy requirements, nonair quality health, and environmental impacts.²³

After all the MACT standards are promulgated, the second phase of Title III requires the EPA to determine whether more stringent standards are required to protect public health with an "ample margin of safety". This phase will have little impact in this decade, although in the future, additional analysis will be required which may lead to another round of aggressive control measures for certain industrial categories. An interesting consequence of the CAAA requires the National Academy of Sciences (NAS) to conduct a review of the risk assessment methodology

EPA uses to determine the carcinogenic risk associated with toxics exposure and to recommend improvements in the methodology.

In addition, the amendments also require regulated facilities to identify certain possible hazardous air pollutants and develop risk management plans to prevent and/or enable response to accidental or catastrophic releases of at least 100 extremely hazardous air pollutants.

3.5 HON Regulation

The HON regulation is the first major MACT regulation the EPA has published under the 1990 CAAA. The EPA considers it to be "one of the most sweeping regulations issued under the CAAA of 1990."²⁷ It establishes MACT standards to reduce emissions of 112 organic hazardous air pollutants from new and existing production processes within the synthetic organic chemical manufacturing industry (SOCMI). The rule also applies to leaking equipment from seven other sources. The EPA estimates national cumulative capital costs will be about \$450 million through the first five years,²⁹ although the Chemical Manufacturers Association estimates the number to be more than \$1 billion.^{1, 2}

The two methods of compliance available under the HON are application of reference control technologies and emissions averaging. The EPA selected reference control technologies (RCT) (pollution control devices) that meet the statutory requirements for MACT and are universally applicable to the particular emission point. In the regulation, provisions are available for receiving permission for using an equivalent or better technology.

Emissions averaging, a new concept for hazardous air pollutants instituted by the EPA, is designed to provide regulatory flexibility for sources faced with unusually high cost compliance scenarios. Regulated facilities may seek approval to comply by averaging the emissions of certain process vents, storage vessels, transfer racks, or wastewater streams subject to the HON regulation.²⁸ The emissions can be quantified to calculate the credits and debits used as an

accounting mechanism for averages. This accounting mechanism allows the regulated facility to over-control at some emission points and under-control at others.²⁷

3.6 Pollution Prevention Incorporated in the HON Regulation

The EPA has endeavored to write the new regulations in a manner to encourage pollution prevention. The pollution prevention encouragement is attempted in two ways, through setting an emission level minimum on process vents below which the emissions are not regulated and the emissions averaging program.

Process vents, roughly defined as a gas stream emission point, storage vessels or tanks, transfer racks for loading trucks or railcars, and wastewater streams from processes and maintenance operations, are divided into two groups for regulation purposes. Group 1 process vents are defined as:

"a process vent for which the flow rate is greater than or equal to 0.005 standard cubic meter per minute, the organic hazardous air pollutants (HAP) concentration is greater than or equal to 50 parts per million by volume (ppmv), and the total resource effectiveness index value, calculated according to §§ 63.115 is less than or equal to 1.0."²⁵

A Group 2 process vent is defined as a process vent that does not meet the Group 1 requirements. The Group 1 process vents must be controlled to the level of the reference control technology, 98% HAP reduction or a reduction to 20 ppmv (parts per million, volume) of HAP, using control devices. There are no control requirements for Group 2 process vents. The similar definitions and control requirements for storage vessels, tanks and wastewater streams can be found in Section 63.111 of Subpart G of the HON rule. The EPA contends the regulation encourages pollution prevention, (like installation of recovery devices for additional product recovery) because if an owner or operator of the Group 1 process vent can reduce emissions enough so the process vent can be reclassified as a Group 2 then there are no control requirements.

The second method for incorporating pollution prevention into the HON regulations is emissions averaging which uses a credit/debit system to demonstrate compliance. The owner or operator must identify all emission points (process vents, storage vessels, transfer racks, and wastewater streams) that would be included in the average and estimate their actual emissions. In the December 1992 proposed HON rule, both existing and new sources could be used, but the final rule only permits existing sources to be used in emission averaging.²⁹ Both Group 1 and Group 2 emission points can be used, although only 20 points may be included in an average (25 points if sufficient pollution prevention projects are included). The final regulation contains additional limitations. Allowable emissions for Group 1 emission points must be calculated and compared to the actual emissions. Any excess becomes emission debits.

Emission credits may be earned in three ways. The first requires implementing a more effective control technology on a Group 1 emission point than that required by the regulations. The second requires using a control technology on a Group 2 emission point and the final requires implementing a pollution prevention project that results in control levels more stringent than required. The EPA requires a ten percent discount factor on all emission credits, except those generated by pollution prevention projects wherein no discount factor is applied.²⁹ For example, a pollution prevention measure, implemented in 1991, is used on a Group 1 process vent but only achieves a 70% reduction in emissions while the required reference control technology would have reduced emissions by 98%. Then, the debit incurred would equal the difference, 28% of the uncontrolled emissions. The owner or operator could then offset these debits through pollution prevent projects on Group 2 process vents to reduce emissions enough to earn the necessary credits.

The proposed regulation would have permitted credits to be calculated on pollution prevention projects initiated after 1987 and on actions taken on Group 2 emission points in

voluntary participation of the EPA's 33/50 program. In the final rule, only actions taken after signing of the CAAA on November 15, 1990 can be used in the average.²⁹

In the final rule, the EPA granted State or local agencies the discretion to not include emissions averaging in their implementation of the rule. This change from the proposed regulation is permitted if emission averaging would be inconsistent with the State or local agency policies or if the resource and/or administrative burden would be excessive.

On October 15, 1993, the EPA proposed requiring sources to demonstrate that compliance through averaging would not result in greater risk than compliance without averaging. The argument is that sources might emit more of one chemical while reducing emissions of a less toxic chemical.³⁰ This is a concern because the emissions averaging program permits any of the 112 regulated chemicals to be offset by any other regulated chemicals. There are no provisions in the regulation for comparison of toxicities. The final rule requires that a proposed averaging plan demonstrate, to the implementing agency's satisfaction, no increase in risk or hazard relative to point-by-point controls. The EPA comments that understanding of HAP toxicity is limited and they will prepare a technical support document outlining procedures to evaluate the risk using existing procedures.

3.7 Comments on the HON Rule

3.7.1 Introduction

The opinions expressed by the interested parties about the rule are important because it's the first major MACT rule and the first attempt at emissions averaging for HAPs. The opinions are important as they identify the concerns each interest group has about the format, structure, and scope of the HON regulation. Thousands of pages of comments are available on the proposed HON rule in its docket within the EPA's Air and Radiation Docket and Information

Center, Wash DC. Portions of the comments are summarized below with an emphasis on those relating to incorporating flexibility and innovation into the regulation, and encouraging pollution prevention. Comment summaries are presented for the following groups: the Natural Resources Defense Council (NRDC), state and local regulators, industry, the National Governors Association, and the American Lung Association. The NRDC is considered the main environmental group interacting with this regulation. The EPA perspective, on the HON rule, is provided in Section V.

3.7.2 Natural Resources Defense Council

The Natural Resources Defense Council (NRDC) submitted extensive comments on the proposed HON rule. The NRDC introduced their comments by calling the emissions averaging program an illegal toxic bubble program forced on the EPA by President Bush's Council on Competitiveness and Office of Management and Budget.³¹ (The bubble program concept is explained in the Glossary.) The comments are divided into six areas of concern including: (1) MACT and the consideration of cost; (2) reference control technologies, efficiencies, and averaging times; (3) emissions averaging; (4) monitoring and enforcing; (5) applicability; and (6) miscellaneous issues.

3.7.2.1 MACT and the Consideration of Cost The NRDC stated that although MACT standards must require maximum achievable emissions reduction, the NRDC concluded these standards cannot be based on cost-benefit or cost-effectiveness analysis. (The EPA used cost of control versus reduction in emissions as part of the evaluation to determine the reference control technologies.) The NRDC stated the MACT floor is not meant to be a ceiling, must be based on actual emissions not cost effectiveness, and should generate improved control not broad exemptions.

3.7.2.3 Reference Control Technologies (RCT), Efficiencies, and Averaging Times The NRDC argued that the HON rule contains sufficient flexibility without the emission averaging program because plant operators can choose between several pollution control devices to meet the RCT requirements. The NRDC expressed concern about using pollution prevention measures to meet emission reductions. Complex analysis and assumptions not susceptible to easy verification by state agencies or the public may be required and extensive monitoring actually demonstrating the required reduction is necessary. They also expressed concern over compliance averaging times, and specifics about the RCT for wastewater and process vents.

3.7.2.3 Emissions Averaging The NRDC opposed the emissions averaging program. They wrote "this unworkable and unenforceable scheme will create paper credits, doublecounting, gaming, and other abuses, just as other bubbles have in the past, if it is included in the final rule."³¹ A legal argument was included which concluded the EPA's definition of source is illegal. Concern was expressed because emission averaging is permitted on different processes and emission points, and allows trading between different pollutants which they state is scientifically and legally indefensible. NRDC stated that indifference to location of sources used in averaging is unacceptable since one point source which is under-controlled may be very close to residential areas or workers. The NRDC also argued that banking of credits should not be permitted and credits should not be allowed for emission reductions accomplished prior to November 1990 since Congress has already provided rewards it thought appropriate.

The NRDC suggested pollution prevention should be encouraged by requiring plants to facilitate community participation, with expert assistance identifying additional pollution prevention activities. Surrounding communities should select the participants in the program; the purpose would be to encourage pollution prevention as a supplement, rather than a substitute for traditional controls. The EPA should then encourage the adoption of the identified pollution

prevention programs by add additional requirements in the MACT standards that all facilities must reduce emissions below the minimum level or demonstrate "after a careful analysis, that doing so is infeasible".³¹ The NRDC contended the emissions averaging program is unenforceable because:

1. EPA's experience with bubbles show they are unenforceable.
2. State agencies do not have the resources to check the averages.
3. Year long averaging will preclude administrative enforcement and violates the maximum achievable emission reductions standard.
4. Implementation plans can be amended by the facility for minor changes without prior approval from the regulatory agency.
5. The HON regulation does not require facilities to complete the performance tests and measurements needed to support the implementation plan before the plan is submitted.
6. The monitoring requirements are wholly inadequate to check the accuracy of credit and debit estimates.
7. Reliable measurement of wastewater emissions is impractical.

The NRDC suggested that, if emissions averaging is retained in the final rule, significant discount factors should be required to compensate for the inaccuracies in assessing compliance and assure the maximum achievable reductions level reflect the cost savings from the averaging.

3.7.2.4 Monitoring and Enforcement The NRDC stated monitoring must be capable of assessing compliance with the required percentage reductions. They felt continuous emissions monitoring of inlet and outlet concentrations should be required whenever technically feasible. The NRDC argued monitoring can not demonstrate compliance for emissions averaging; their justification includes:

- * monitoring is ineffective as a system for checking an emissions average because it only verifies attainment of a reference control efficiency,
- * emissions averaging is a system depending on predictions of future emissions and is therefore inherently unenforceable,
- * and gaming is allowed because unchecked emissions estimation is based on representative operating conditions.

The NRDC expressed concern over the new parameter monitoring program and suggested modifications. (The parameter monitoring program is explained in the Glossary.)³² Finally, the NRDC recommended the EPA require companies to establish community ambient monitoring programs. Such monitors would be useful in helping communities document claims of possible air pollutant dumping at night.

3.7.2.5 Applicability The NRDC requested the EPA significantly increase the scope of the HON rule. They recommended the HON rule be modified to regulate non-synthetic organic chemical manufacturing industry (SOCMI) emission points, mixed processes (facilities with both HON regulated processes and processes not covered by the HON rule), non-major sources, marine loading operations, and batch process vents.

3.7.2.6 Miscellaneous Issues The NRDC contended the EPA should require control of all emission points, not just Group 1 points, (Group 1 and 2 emission points were explained on page 20) particularly those emitting high-risk pollutants. They are concerned the floors determined for the HON MACT standards are too low and much stricter RCT standards should be required.

The NRDC recommended the EPA include a more specific implementation schedule for compliance with the regulation to ensure companies are moving to reduce emissions as

expediently as possible. They also believed the pollution control expenditures required by this rule will significantly benefit the economy and have no significant financial impact on the regulated companies.

3.7.3 State and Local Regulators

Many regulatory agencies and several regulatory groups provided comments on the proposed HON rule. The general areas of concern are summarized below with emphasis on emissions averaging. The majority of comments are from the State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO), the main organization of state and local regulators. The comments are divided into four areas: (1) emissions averaging, (2) cost-benefit issues, (3) control technology issues, and (4) related documents.

3.7.3.1 Emissions Averaging STAPPA and ALAPCO disliked the emissions averaging program because they oppose the use of "bubbles" to meet MACT standards.³³ They are particularly opposed to allowing new sources in the emissions averaging because new sources must meet more stringent requirements according to Title III and it is "most cost effective to install state-of-the-art controls on a unit when it is new".³³ STAPPA and ALAPCO insisted that state and local air agencies must reserve the right to implement the MACT standards without the emissions averaging provisions.

The Texas Air Control Board (TACB) argued emissions averaging across the entire facility can not be legally justified and MACT must require installation of the appropriate control technology on each emission point.³⁴ They believed the emissions averaging program will be very resource intensive because of the quantity of data required to document compliance. The

TACB stated the resources required to administer the emissions averaging program will increase the regulator workload by a factor of three to four.

STAPPA and ALAPCO argued, historically emissions averaging programs have caused severe administrative burden and are virtually impossible to enforce. They stressed that "although averaging may appear to be cost-effective in the short-term, other administrative burdens, such as tracking, record-keeping and enforcement, will be a long-term financial strain for industry, as well as for state and local agencies."³³

STAPPA and ALAPCO were also concerned that the proposed HON allows averaging among different types of emission points. Their comments stated the impacts of emissions from different types of source points can vary significantly if they have different emission characteristics that influence dispersion. For example, the height of emissions, location with respect to the property line, volumetric flow, stack gas temperature, and the continuous or intermittent character of emissions influence on air quality. These variations in emission characteristics are not addressed in the emission averaging program. Wastewater emissions are also extremely difficult to measure.

The Northeast States for Coordinated Air Use Management (NESCAUM) contended the emissions averaging program contains inadequate performance testing, monitoring, recordkeeping, and reporting requirements.³⁵ They are concerned averaging will require extensive monitoring and recordkeeping in order to ensure the various averaged sources achieve the same net emission rate that would be achieved using the required reference control technologies. NESCAUM also stated that a significant increase in enforcement resources will be required to ensure the emissions averaging limit is both verifiable and consistent with all permit conditions. NESCAUM did not support the use of credits based on emission reductions from the 33/50 Program because these credits do not reflect actual reductions required by the HON regulation and would result in doublecounting.

STAPPA and ALAPCO were opposed to allowing emissions debits to exceed emission credits by 25-35% in a quarterly reporting period for two reasons. First, they were concerned about the possibility of a release of a high concentration of excess toxic emissions being released in a short time period. Second, they were disturbed about the possibility of a facility accumulating a large quantity of debits and being unable to produce the required adequate credits to offset the emissions.

STAPPA and ALAPCO were resistant to the annual compliance period because they believed it will cause enforcement and administrative difficulties. They were also opposed to the banking provisions of the rule and the broad averaging ideas discussed in the preamble. They did support a large discount factor because of the uncertainties of the data used in the averaging and to insure the environment also benefits from the flexibility and cost savings. The California Air Resources Board suggested the "relative value" of credits should be adjusted for pollutant hazards.³⁶

STAPPA and ALAPCO contended the philosophy behind the emissions averaging program is flawed because the new source averaging program allows a new source to avoid installing the best controls available as required by the statute. Therefore, if the control technology and procedural requirements required in the rule are achievable, then new sources should not be allowed to avoid them through averaging. The Maryland Department of the Environment argued that new sources should not be included in the emissions averaging program because "it is poor environmental policy to allow new sources to use emissions averaging to avoid good control technology or pollution prevention measures to minimize emissions."³⁷ They also contended that when new equipment is being designed and built it is appropriate for regulators to push process design engineers to look for pollution prevention opportunities.

STAPPA and ALAPCO were also concerned with the interpollutant trading allowed because the proposed HON rule fails to include a system for ensuring that this trading will not

be a threat to public health. They contended the EPA's proposed rule does not adequately account for the varying toxicity, bioaccumulation, possible synergistic effects of hazardous air pollutants, and could allow interpollutant trades that increase health risks to the public. STAPPA and ALAPCO provided recommendations on developing a credible hazard ranking system to address the interpollutant trading issue. They recommended the EPA:

1. "rank all HAPs by relative toxicity into groups with a similar degree of noncarcinogenic toxicity, taking into account bioaccumulation and non-inhalation pathways;
2. rank separately all HAPs into groups based upon relative carcinogenic effects, taking into account bioaccumulation and non-inhalation pathways; and
3. allow an increase of a HAP to be offset only by a decrease of an equal or greater amount of the same HAP or of another HAP that is in a more toxic group on one scale and that is not in a less toxic group on the other scale."³³

They further recommended use of the more hazardous pollutant approach instead of the more hazardous quantity approach because the later relies too heavily on the small database that exists to characterize the toxicity of pollutants.

3.7.3.2 Cost-Benefit Issues STAPPA and ALAPCO were strongly opposed to the use of cost-benefit analysis by the EPA to set the floors for the MACT standards. They believed this analysis is illegal and attempts to assign a dollar value to the benefits of pollution reduction.³³

3.7.3.3 Control Technology Issues STAPPA and ALAPCO were concerned the EPA did not use current data in developing the floors therefore the floors are set too low. They were also opposed to the exemptions. NESCAUM protested the exemption of batch operation processes because "(1) they tend to be used in older facilities that are significant sources of HAP emissions and (2) batch processes are currently regulated by [some] state air quality programs in the Northeast."³⁵ STAPPA and ALAPCO provided specific information on various control

technologies like destruction efficiencies, performance testing requirements, and related problems with operation.

The State of Wisconsin, Department of Natural Resources, recommended the EPA develop a mechanism to insure timely determination of a reference control technology rating for new control methods. An expedient approval process would encourage innovative methods for HAP control.³⁸ The Texas Air Control Board recommends the EPA require monitoring of Group 2 emission points (those emission points not required to be controlled) to insure compliance.³⁴

3.7.3.4 Related Documents The California Air Resources Board (CARB) stated the scope and ramifications of the HON rule can not be properly evaluated without several related documents that are not yet promulgated. For example, the proposed HON rule references extensively the General Provisions of NESHAP for Source Categories, (40 CFR 63, Subpart A), but this regulation has not been published or distributed to the public. The CARB recommended the HON should not be implemented or enforced without finalization of several documents.³⁶

3.7.4 Industry Comments

Many companies provided comments on the proposed HON rule, but the most comprehensive, thorough response was provided by the Chemical Manufacturers Association (CMA). The following summary follows the CMA comments with additional comments from specific companies where appropriate. Again, this summary emphasizes the companies opinions on the innovative and flexible portions of the proposed rule, in particular the emissions averaging program. This summary is divided into eight areas: (1) introduction; (2) applicability; (3) determination of MACT; (4) compliance; (5) monitoring, recordkeeping, and reporting; (6) emissions averaging; (7) wastewater; and (8) other.

3.7.4.1 Introduction The CMA started their comments by introducing themselves as a nonprofit trade association whose member companies represent more than 90% of the productive capacity for basic industrial chemicals in the United States. The CMA stated it has a vital interest in the proposed rule, is committed to stringent control of HAP emissions, and supports the EPA effort to promulgate the MACT standards.³⁹

The CMA expressed concern over the high cost of implementing the HON rule. In addition to the initial capital costs, the proposed HON will significantly increase maintenance, operating, and administrative (for monitoring, recordkeeping, and reporting) costs. Considerable documentation was provided. The CMA provided specific recommendations for making the rule more "user friendly", understandable and achievable.

3.7.4.2 Applicability The CMA, in general, supported the applicability criteria proposed to define the scope of the regulation and the various definitions. Some recommendations are provided. The CMA expressed concern about overlapping regulatory requirements like NSPS and the Benzene NESHAP. They recommended the HON rule be written so that the HON requirements will override all other overlapping or inconsistent regulatory requirements. The CMA also recommended all references to unpromulgated regulations should be deleted because the HON rule can not be implemented if referenced documents are not finalized.³⁹

Ashland Petroleum Company expressed concern that petroleum refineries, or portions of, might be regulated under the HON rule because petroleum and SOCOMI facilities are often co-located. They emphasized petroleum refineries are to be regulated under a separate MACT rulemaking and should not be affected by the HON rule.⁴⁰

3.7.4.3 Determination of MACT The CMA stated the EPA has done a reasonable job in determining the minimum statutory requirements for controlling emissions, although the EPA method used overstates the MACT floor (the MACT floor definition was provided on page 18).

"In identifying the MACT floor for the HON, EPA has identified a separate floor element for each emission-point type and has aggregated the emissions reductions achieved by those technologies to calculate a single floor for the entire category. Using this additive approach to develop the MACT floor (using the best controlled process vents, storage tanks, etc.) has inevitably resulted in a MACT floor (and resulting standard) for the HON that is more stringent than would be developed by examining the total emissions from the best-controlled SOCMI plants. For purposes of setting the MACT floor, therefore, EPA has essentially treated SOCMI as five source categories rather than one - with a substantial increase in the stringency of the floor calculated for the category as a whole."³⁹

CMA stressed the statute requires the cost of emission reduction must be considered in order for MACT to exceed the statutory floor. Therefore, the proposed MACT standards exceed the floor but without the appropriate cost consideration and justification.

The CMA contended the Group 1 and 2 distinction is reasonable and acceptable under the statute. But they are concerned the EPA method of considering costs and benefits is grossly inaccurate because of the overly simplistic plant model and other data used by the EPA. The CMA believed the MACT standards should not exceed the floor because of the cost.³⁹

The CMA stated that multimedia impacts, more specifically the generation of NO_x, CO, and SO₂, other waste generation, and energy requirements, need more thorough evaluation. CMA conducted several studies and concluded that some regulated facilities, in nonattainment areas, may not be able to comply with the HON requirements because of Title I requirements. The CMA went further to recommend the following provision for addition to the HON rule:

"If the owner or operator of a source demonstrates that by employing any of the Reference Control Technologies listed in Subpart G to an emission point (process vent, storage tank, loading rack or wastewater handling/treatment unit) the negative environmental impact that would result from such control, when taking into account impacts to all environmental media (air, water, and solid waste) would be greater than without the application of such control, then the control of such emission point is not required." (emphasis added)

A similar provision is provided for an Alternative Control Technology or work practice.

Eastman Chemical Company provided an example of the inappropriateness of some of the HON requirements. At one of their facilities, they must install additional expensive control equipment to meet, what they consider to be the complex, unwieldy HON requirements. These new RCTs will not appreciably reduce HAP emissions but will significantly increase emissions of NO_x, TSP, VOC, SO₂, and CO from the facility.⁴¹

3.7.4.4 Compliance The CMA asserted "compliance records are extremely important to companies as they strive to maintain the trust and respect of their surrounding communities, their shareholders, and regulatory officials."³⁹ Therefore, it is vital to create a compliance scheme under the HON that will ensure that the standard is met, but will safeguard against companies being unfairly penalized.

In general, the CMA supported the use of prescribed RCT for achieving the required level of control with the provisions for alternative compliance measures like emissions averaging. The CMA agreed with the use of site specific representative operating parameters to measure the proper operation of control devices and suggest increasing the availability of extensions to compliance because of expected delays in permitting, equipment, and engineering. But, this provision must be easy to implement to be useful.

The CMA supported the provisions that allow a percentage of excused deviation periods from daily average control device parameter values. These provisions are necessary because numerous events, like weather, can cause a control device to deviate from prescribed parameters despite the best efforts of the operator.

The Monsanto Company recommended the alternative means of emission limitation provisions under general standards in the proposed rule should be streamlined and used to encourage innovative and cost-effective means to achieve MACT. (These provisions provide a mechanism, through the EPA Administrator, to receive approval for alternative methods of

compliance.) Specifically, they recommended insuring the monitoring, recordkeeping, and reporting requirements do not exceed those required by using the RCT and eliminating the requirement for a public hearing.⁴²

3.7.4.5 Monitoring, Recordkeeping, and Reporting The CMA expressed concern over the high cost of meeting the monitoring, recordkeeping, and reporting requirements. CMA member companies estimated these requirements will necessitate an additional 0.5 - 1.5 person-years of effort for each process unit. The CMA realized some of these efforts are necessary to demonstrate compliance, but money spent on monitoring, recordkeeping, and reporting have no direct environmental benefit and should be minimized. Recommendations included allowing validated data compression systems for use with monitoring and recordkeeping systems, minimizing continuous monitoring requirements on Group 2 emission points, and reducing report requirements.

3.7.4.6 Emissions Averaging The CMA commended the EPA for developing an emissions averaging program that was a viable alternative for regulated facilities and an environmentally beneficial approach to emissions control. The CMA believed many sources will need this alternative to meet some of the impracticable HON requirements. CMA supported the emissions averaging approach and recommended the EPA streamline the final rule to ensure innovative methods of emission control are encouraged. Specifically, facilities that try these new methods should not be penalized with more stringent monitoring, recordkeeping, and reporting requirements than those facilities using only RCT.

The CMA provided considerable information and documentation supporting the legality of the emissions averaging program, arguing it is consistent with the 1990 CAAA statutes, and the EPA definition of source is reasonable. The CMA went further to argue the EPA could

promulgate a simple numerical emissions limit for sources in the category, leaving it up to each individual source to decide how to meet that limit.

"The statute itself requires that approach be adopted where feasible; under section 112(h), standards are to be specified, as numerical emission limits rather than as design, equipment, work practice, or operational standards. Section 112(h). This directive reflects Congress's intent that the emission reductions required by the statute be implemented in a flexible and cost-effective fashion."³⁹

The CMA supported the proposed annual compliance period with quarterly limits, and the banking of credits provisions. The CMA argued that emissions averaging should be extended to all, new and existing, emission points within the source that emit HAPs, including emission points not included within the SOCOMI source category. The basis of their argument is that when a facility is regulated by more than one MACT standard, the only statutory requirement is that the entire facility must have an overall degree of reduction, that is the sum of the reductions required under those standards.

The CMA supported the proposal to permit the use of pollution prevention projects for generating emission credits. They recommended the EPA definition of recycling be expanded to include out-of-process recycling.

The CMA argued there should be no baseline date for credits (the proposed HON uses November 1990 for all but specific pollution prevention projects which are 1987). Setting a baseline date for credits derived from controls on Group 2 points or overcontrol of Group 1 points negates the main objective of emissions averaging, which is to allow a source to achieve the overall level of emission reduction (constituting MACT) through the most efficient means possible. Using a baseline may encourage operators to merely move controls from Group 2 to Group 1 points. Finally, there is a basic unfairness in penalizing sources that installed controls "too early". Logically, rewards given to sources that reduced emissions early should, if anything, be greater, not lower. Monsanto also argued the prohibition of using production cutbacks and shutdowns to generate credits is inappropriate. One example is a facility determines

it is more cost effective to close one Group 1 process unit and significantly upgrade a second Group 1 process unit. The overall drop in emissions by closing the first line is significant and should be useable to generate credits.⁴²

The CMA did not agree with the discount factor on credits. The CMA anticipated emissions averaging will not reduce costs below the average levels projected for RCT because most facilities will only attempt the program if the RCT costs are exceedingly high for particular equipment. The CMA discussed the major differences between this emissions averaging program and the Title I bubbling programs and why they are not comparable. Finally, the CMA disagreed with the EPA argument that, to be conservative and to adjust for uncertainties, the use of a discount factor is justified. CMA contended the requirements for using the emissions averaging program are already more stringent thus most sources will endeavor to design and operate their emissions averaging program in a manner that yields an excess credit margin of safety.

The CMA argued that the appropriate methodology for calculating risk should not be addressed in the HON rule because the statute gives the EPA the authority to allow emissions averaging without ranking pollutants by toxicity. They believed Congress did not want to slow the regulatory process with the uncertainties of health risk assessment. Additionally, even if risk-based restrictions on inter-pollutant averaging were appropriate, EPA does not have sufficient data to design and implement such restrictions. Therefore, no restrictions should be placed on averaging emissions of different pollutants.

3.7.4.7 Wastewater The CMA had serious concerns about the wastewater requirements. They believed the EPA has failed to support steam stripping as the RCT. The CMA requested the EPA provide a pure performance standard and then allow facilities to design a treatment program to meet those requirements using approved computer simulation techniques. The CMA provided considerable data, scientific studies, and reference documents in an attempt to convince

the EPA that biological treatment should be designated as an additional RCT. The CMA discussed at great length other concerns they have with the wastewater requirements.³⁹

3.7.4.8 Other The CMA provided considerable comments and recommendations on various test methods referenced or included in the proposed HON rule. The CMA supported, with a few modifications, the initial notification, implementation plan and notification of compliance status as the initial reporting requirements. The CMA also supported the emission control requirements on transfer racks with only a few suggestions.³⁹

The CMA contended the EPA has failed to justify the option selected for process vents as the proposed control level or RCT because costs and emissions benefits were not properly evaluated. They also identified several technical issues concerning the ability of the RCT to meet the necessary emission percent reductions of HAP.

The CMA supported the proposal to allow facilities to make improvements on existing HAP storage tanks as an alternative to installing control devices. However, they questioned several of the specific requirements for control levels for various tanks.

3.7.5 Additional Comments

The National Governors Association (NGA) endorsed the emission averaging program among existing sources as long as a system is developed that adequately accounts for varying risk, appropriate discount factors, and sufficiently restrictive averaging periods. They concluded that the emissions averaging program "could benefit the environment and provide industry with flexibility to meet environmental objectives."⁴³ The NGA expressed concerns about allowing new sources to be used in the emissions averaging program and the limited "tools" available to evaluate risk equivalency.

The American Lung Association (ALA) had three main concerns: "1) the inappropriate use of cost-benefit analysis to determine the control technology floor for source categories and as justification for exemption of certain source categories from control requirements altogether; 2) flaws in the emissions averaging proposal, and 3) exemptions for a large number of significant sources of hazardous air pollutants ... as regulated source categories."⁴⁴ Their specific concerns about emissions averaging include too broad a scope, the potential increase in emissions of high toxicity pollutants, the possible negative effect of longer averaging times on program effectiveness and enforcement, and the proposed credit for pollution prevention projects installed prior to the passage of the 1990 Amendments. The ALA expressed concern that it would be extremely difficult for state/local air pollution control agencies to effectively analyze the baseline emission calculations and then monitor emissions from a large number of diverse emission points. The ALA also believed the regulatory benefits, the potential public relations benefits and the economic benefits are sufficient to encourage pollution prevention projects.

3.7.6 Significance of Comments

The comment summaries illustrate the range of concerns and polarized viewpoints between the interested parties. The NRDC was concerned the proposed HON rule was not strict enough, accomplished too little to protect people, and contained too many loopholes for industry to avoid compliance. State and local regulators wanted a simple, implementable, enforceable, verifiable regulation that would not completely inundate their work force. Industry indicated a willingness to work with the EPA and other regulators, but were concerned with the immense cost of compliance. Industry provided comments to make the regulation more flexible, implementable, and simpler.

The difference in opinions on flexibility, innovation, and pollution prevention issues is important. The negative comments were so forceful as to cause (along with other factors) the

significant narrowing of the emissions averaging program in the final rule. The importance of these comments and their impact on the final HON rule is further discussed in Section V, the EPA Dilemma.

IV. Regulation Shortcomings

4.1 Introduction

The history of environmental management in the United States of America centers on the activities of the Environmental Protection Agency. Since the Agency's creation in 1970, it has been responsible for the regulation of pollutants into the environment and subsequent gradual clean up of the air, land, and water of this country. Through the establishment and subsequent enforcement of those regulations, the EPA has forced a culture change on the way business is conducted. Thirty years ago businesses, industries, etc merely dumped their wastes into the environment. Today most wastes are regulated, some with strict requirements. Many large businesses and industries have dedicated people working in environmental management and compliance, and they spend a considerable amount of resources attempting to comply with the increasingly complex environmental regulations.

Over the decades, the EPA has evolved. The NESHAP history was discussed earlier. The EPA has learned how to write and implement regulations, and how to win some of the legal battles that ensue. The EPA has recently started to develop programs that work with regulated community and local regulatory agencies to develop better programs.

As the EPA's regulation writing process continues to evolve, it is beneficial to summarize the current analysis of regulation shortcomings. Problems with current regulations and applicable recommendations are summarized below from three sources: a study summarizing recommendations following a special joint EPA, Amoco Yorktown Project; a study done by Environmental Management Consulting for the EPA; and the 1993 EPA National Performance Review report from the pollution prevention team.

4.2 Observations from the Yorktown Project

The "Yorktown Project" was a joint EPA and Amoco venture to study pollution prevention opportunities and barriers to innovation. The project was conducted at a small, 35-year old refinery in Yorktown, Virginia. The EPA and Amoco conducted an emission inventory of the facility, identified pollution sources, and identified and subsequently ranked pollution reduction alternatives appropriate for the facility. The ranking system was based on reduced overall pollution compared with cost of implementing. Many identified alternatives incorporated cross media pollution reduction and pollution prevention concepts.

At the conclusion of the project, EPA and Amoco evaluated the requirements that they thought would be required under new CAAA regulations and calculated a required reduction of about 7300 tons a year of hydrocarbon emissions from multiple sources at an average cost of \$2400 per ton. Then the team compared the emission reduction alternatives identified by the project. The alternatives could capture about 7500 tons of emissions at a cost of \$500 per ton. Some of the alternative emissions reductions were from unregulated sources and multi-media effects (for example, reduction of some hazardous waste).

In a summary of the project, three lessons learned and three opportunities to promote innovation were listed; they are:

- * Government and industry can work together. However, current institutional practices discourage innovative solutions to environmental problems. The biggest concern is not the goals, but rather the means to achieve the goals.
- * Improved data can improve environmental decisions. Too many decisions are made without enough accurate data. Although obtaining data is expensive now, it is cost effective in the long run.
- * Risk-based decisions, while complex, offer the ability to focus resources on significant problems and more effective solutions. Risk-based decisions allow industry to determine the benefits of different choices in terms of impact on human health and environmental quality.
- * Reliance on performance standards instead of technological design standards is preferred. The people who have to work with facilities should determine the best way to meet standards.

- * A safety net to encourage people to try new things must be created. Currently, if a company tries something new and comes up with 95 percent success instead of 100 percent, they are essentially back to ground zero and have to start over. This is an expensive proposition.
- * If a facility shows an overall net reduction of emissions for sources at a particular site, EPA should consider the reduction to be valid. This is cost-effective because it allows facilities to over-control some sources and under-control others.⁴⁵

A followup report, "Effective Environmental Strategies: Opportunities for Innovation and Flexibility under Federal Environmental Laws", was completed as a result of the Yorktown Project which identified opportunities for new approaches to environmental management. The report identifies and discusses 17 opportunities for increasing innovation and flexibility in the regulatory process. Three, pertinent to this research project, will be summarized. First, give priority in the regulatory process to innovative technology waivers and allow facilities flexibility in achieving the required emission reduction standards. Second, tailor regulations to environmental risks, promote pollution prevention and define wastes to encourage recycling. Third, develop facility-wide performance standards (versus specific sources), set on ultimate risk level, emission reduction standard or other similar standard.

The report also provides general conclusions and recommendations for improving environmental management in this country. One conclusion from the Yorktown project is that continued use of the current command and control style of environmental legislation and regulation discourages innovation, particularly in pollution prevention projects. The command and control style is generally defined as the EPA dictating which pollutants and sources must be controlled, to what extent, and which technology must be used.

A second key conclusion reflects on the overall objectives of environmental regulations: less pollution and reduced risk to people and the environment. The report concludes the country can more effectively meet those objectives if regulated facilities are allowed to devise their own plant-specific compliance plans.

A third conclusion summarizes two shortcomings of current environmental regulations. First, because regulations are single media or of limited focus, they ignore the multi-media impacts of a particular regulation and fail to account for the technological and logistical issues associated with overlapping regulations. Second, because of the speed of technological progress and the slow process of regulation promulgation, mandated technologies are often obsolete before compliance begins.

A fourth conclusion provides three elements necessary to promote innovation. First, the regulated facility must have the opportunity to prioritize its efforts based on the effectiveness in reducing or preventing pollution, regardless of the source. Second, public and private institutional obstacles and disincentives must be minimized. Third, a partnership must develop between the EPA, the facility, the state and the community which focuses more on the results of environmental protection, rather than strictly on the methods used to achieve the results.

The report's final conclusion comments on the natural reluctance to change, especially when philosophies must change and a greater effort is required. The long term benefits to the environment, the public, and industry are worth the effort. As complexity of environmental regulation and the associated cost of compliance continue to escalate, the benefits of incorporating these concepts into the compliance strategies become increasingly evident.⁴⁶

4.3 Pollution Prevention Activities Incentives Study

In 1993, Environmental Management Consulting completed a study for the EPA on incentives available for industry to engage in pollution prevention activities.⁴⁷ The one year study involved personal interviews with individuals from 317 diverse companies. The study findings include five key areas that encourage or discourage pollution prevention throughout industry. The areas are: flexibility, multi-media solutions, major impediments to pollution

prevention, effective communication, and involvement level. The first three relate to this research project.

Flexibility can be incorporated into performance standards, individual plant measurement, technical flexibility, and inspection and enforcement. The study concludes the way to develop pollution prevention technologies and emissions reductions rapidly is for industry to work with EPA to develop industry-specific performance standards. Industry considers themselves most qualified for the task because they know the processes better. Industry would like to assist EPA in developing accurate methods for measuring their individual facilities. The study acknowledges that considerable trust would be involved and parties would have to learn to work together. Technical flexibility is better for business than having the EPA prescribe pollution control technologies. When regulations include specific technologies, the creativity and innovation of industry is stifled. Given specific requirements, most business (and people) would rather be challenged to look for a solution within a reasonable time frame.

The study recommended the EPA develop a multi-media permitting system. Most regulated industries have compliance requirements in several media and must obtain permits under the various media regulations. A multi-media permitting system would reduce paperwork requirements, reduce duplication and conflicts, and emphasize pollution prevention projects that reduced pollution from several media. In comparison, many pollution control devices merely shift the pollution from one media to another.

The study identified eight major impediments to pollution prevention. They include:

1. Permitting time. Long permitting time was determined to be the single largest impediment to companies trying to implement pollution prevention technologies. Companies are forced to be conservative, particularly when there are no provisions for at least partial compliance for trying a new technology.

2. Cost. Historically, pollution prevention has not been incorporated within regulations, therefore it is viewed as an extra program by business and must be justified by cost savings entirely.
3. Research and development (R&D) resources. Because regulations rely on end-of-pipe control technologies, businesses are encouraged to invest limited R&D on the same. There is little incentive to use R&D resources on unproven pollution prevention technologies, particularly because there are no provisions for some level of compliance if the new technology should prove less than completely effective.
4. Regulatory uncertainty. Uncertainty of future regulations limits investments in pollution prevention.
5. Process complexity. Facilities with complex processes often require complex pollution prevention projects which are often more difficult to identify, implement, and justify compliance than with simple projects.
6. Business risk. Trying new technologies can also be a business risk, particularly when involved in a competitive bid process where using proven technology is required.
7. Cost accounting. Currently, there is no standardized accounting method for demonstrating the cost of not preventing pollution. Accounting standards are needed to convince financial managers of the value of pollution prevention projects.
8. Fee structure. The study also recommended the fee structure be adjusted to reward businesses that attain an emissions level below the required level.⁴⁷

4.4 EPA's National Performance Review

In August 1993, the EPA Pollution Prevention Team published a National Performance Review (NPR) intended to identify and promote progress in developing and encouraging pollution prevention. The NPR was done in response to the EPA Administrator's outreach efforts on pollution prevention and contained general conclusions and specific recommendations to further pollution prevention.

Two conclusions from the review provide insight into improving the incorporation of the pollution prevention ethic into EPA's operations. First, the EPA should provide flexibility in its regulatory programs to encourage pollution prevention solutions to compliance issues (emphasis added). Second, "Innovation and risk-taking must be rewarded not punished". The review concluded that the EPA must work towards encouraging the regulated community to commit to and invest in strategic, forward-looking approaches to environmental management.

Also, the NPR lists 28 specific categories (areas to be targeted and actions to be taken) and featured initiatives. Three of the identified categories relate to this research effort and are summarized below. First, the EPA should change its organization and culture to make pollution prevention the central operating principle of the organization. The NPR recommended the EPA restructure itself to promote risk taking, exposure reduction, and pollution prevention.

Second, the EPA should incorporate pollution prevention into all programs, including regulation development, compliance activities, and research. The NPR recommended the EPA develop and implement every regulation and related document to integrate pollution prevention into the options available for compliance. Third, flexibility in permit compliance should be increased to encourage pollution prevention, and the EPA should cultivate public and private partnerships to foster pollution prevention.⁴⁸

The central theme in these three studies is the realization by both the EPA and regulated industry of the value of pollution prevention in environmental management. Pollution prevention

can be encouraged through flexibility and performance based standards in regulations and through cooperation between the affected parties. The EPA should strive to develop regulations that incorporate the concepts identified in these reports, and in turn the regulatory community will have to work with the EPA and be willing to try new methods of environmental management.

V. The HON Rule Evolution

5.1 Introduction

EPA is attempting to overcome the shortcomings identified in Chapter 4. There is a seemingly endless stream of pamphlets, articles, and speeches on the efforts EPA is taking to incorporate flexibility, innovation, and pollution prevention into its regulations and operations. To gain an understanding of how difficult this is to accomplish, a study of the HON rule evolution provides an enlightening example.

Section 5.2 begins the study of the HON rule with an analysis of the goals defined by the EPA for the HON rule while it was under development. In Section 5.3, the limitations on the final HON rule and the EPA justification is discussed. Section 5.4 acknowledges the accomplishments the EPA has made in incorporating pollution prevention into the Title III regulations.

5.2 Original Intent of the EPA

Prior to any formal rulemaking under the 1990 CAAA, the EPA developed the Hazardous Air Pollutants Strategic Implementation Plan to clarify the philosophy to be used by the EPA to implement Title III.⁴⁹ The strategic plan defined EPA's major goals to be:

1. "Identify significant sources of air toxics emissions,
2. Establish timely, efficient and flexible regulations to achieve the maximum degree of emission reductions practicable,
3. Employ a consultative open rule-making process to consider the views of major concerned parties,
4. Focus rule-making efforts on pollution prevention strategies,
5. Leverage all available resources through cooperative agreements with states, industry and others to secure required information,

6. Leverage the benefits of the toxic program through voluntary reductions, incentives for early reductions and coordination with other programs to maximize air toxics reductions."

The Plan also outlined the top six priorities for achieving the requirements of the CAAA with limited Federal funds. They are:

1. Focus on the best opportunities for risk reduction,
2. Meet near-term statutory mandates in the most cost effective manner possible,
3. Promote pollution prevention and other innovative solutions,
4. Restructure the EPA's regulatory process to better achieve the long-term requirements of the CAAA,
5. Promote research aimed at bettering understanding health and ecological risks, and
6. Leverage resources to provide the most efficient and effective implementation program.

With this guidance the EPA HON regulation team, headed by Dr. Janet Meyer at Research Triangle Park, NC developed the proposed HON rule summarized in section III. Portions of the preamble describe what the regulation team attempted to accomplish and some of the difficulties encountered as they attempted to incorporate innovation, flexibility, and pollution prevention into the rule.

In the preamble of the proposed HON rule, the EPA defines several goals, aside from the general goal of maximum achievable emissions reduction. These goals include: "overall administrative simplicity, allowing flexibility in implementation in order to reduce costs, encouraging pollution prevention, and ensuring enforceability."⁵⁰ The EPA concludes some goals such as flexibility and encouraging pollution prevention reinforce each other, and other goals may seem contradictory such as flexibility and enforceability. In the rule, the EPA states they attempted to find a workable balance among the goals. Under the emissions averaging discussion in the preamble, the EPA goes further by stating "emissions averaging provides

sources the flexibility to comply in the least costly manner while still maintaining a regulation that is workable and enforceable."⁵⁰

The HON regulation team attempted to set a precedent to encourage future participation in voluntary emission reduction programs and reward innovative pollution prevention efforts through the emission credits. The proposed rule allowed sources to earn emission credits for a control action taken before November 1990 if the action achieved more emission reduction than required and was a pollution prevention measure taken after 1987, an Early Reductions, or a 33/50 commitment.⁵⁰

Although the emissions averaging concept was new in regulating hazardous air pollutants, the EPA regulatory team attempted to make the emissions averaging provisions even broader in two ways than the program described in Chapter 4. First, the EPA proposed allowing a broader emissions averaging alternative. The 1990 CAAA prevents averaging across sources but the EPA proposed allowing averaging of emissions from points located anywhere within an entire contiguous facility containing HON-covered processing units. After considerable discussion of impacts and requirements, the EPA suggested three advantages to this concepts. First, companies could achieve the same environmental gains, but possibility at significantly reduced costs. Second, the MACT floor for future standards might be tighter because of controls implemented on emission points to be regulated in the future. Third, emission points might be discovered within facilities that otherwise might have been overlooked by the EPA, state, and local regulators.

The second method by which the EPA attempted to broaden the emissions averaging provisions was to allowing credits for recycling activities. In the preamble, the EPA state they are "willing to include provisions in the final rule for crediting recycling if sufficient information on quantification, methodology, and enforceable mechanisms for such recycling measures is received during the public comment period."⁵⁰

5.3 Rationale for Limiting the Final HON Rule

When the final rule was published the emissions averaging compliance option was limited. A summary of the changes is shown in Table II. As discussed in section 3.5, the emission averaging portion of the final rule allows only existing sources (not new and existing), limits the number of emission points to 20 or 25, requires a discount factor on most credits, severely limits the banking of credits, and only permits use of actions taken after 1990 to generate credits. Furthermore, monitoring, recordkeeping, and reporting requirements are more rigorous than the RCT method of compliance. The final rule allows state and local regulators to disallow this method of compliance and requires sources to demonstrate no relative increase in risk over the RCT method of compliance.

Table II. Narrowing of the Emissions Averaging Program

Provisions	Proposed Rule	Final Rule
Types of Sources	New & Existing	Existing
Number of Sources	Unlimited	20-25
Discount Factor on Credits	None	10% Except PPP ¹
Credit for Early PPP	After 1987	After 1990
Banking of Credits	Up to Five Years	None
Risk Evaluation	None	Demonstrate no Increase

Where: ¹PPP - Pollution prevention projects

EPA's rationale for limiting the emissions averaging program is partially documented in the preamble of the final HON rule and additional justification is available from the EPA personnel involved in finalizing the rule (Office of Air and Radiation, Office of Enforcement and Compliance Assurance, and the Office of Air Quality Planning and Standards).

The flexible, and innovative provisions within the HON rule were limited because of the many negative comments received, the political climate, and the EPA's historic perspective and experience in writing, implementing, and enforcing rules. The EPA was concerned about the potential resource burden on state regulators and the difficulty in enforcement of the emissions averaging program. The regulators and even the environmental groups are familiar and comfortable with the RCT or end-of-pipe control method of regulating pollutants along with its prescriptive requirements and standard inspection manual form of enforcement. There were many concerns about implementation problems, and educating and training regulatory people to work with diverse compliance plans. The issue of whether the emissions averaging program would only allow credit for existing pollution prevention projects instead of forcing new emissions reduction could not be resolved.

In the final rule preamble, the EPA defined the purpose of the emissions averaging provision as allowing an alternate compliance method for "sources faced with some emission points that are particularly difficult or costly to control."²⁹ The purpose is no longer to encourage innovation and flexibility. Interviews implied that although the EPA is attempting to incorporate pollution prevention within the MACT rules, they are more concerned the finished rule can ensure credible, verifiable, enforceable compliance, and addresses toxicology issues. The preamble further explained some of the changes by stating "some provisions have been altered or added in order to sharpen the focus of emissions averaging, ease implementation and administration, and ensure at least the same air quality benefit as point-by-point compliance."²⁹

The broader scope of the emissions averaging provisions discussed in the proposed rule preamble was not implemented in the final rule. The EPA justified this decision by stating after considering "all of the arguments put forth by commenters, both supporting and opposing broader averaging, the EPA has concluded that emissions averaging on a broader scope cannot be legally justified."²⁹ The dilemma is sources that eventually will be a part of separate MACT standards

can not be included in an emissions averaging program because after all applicable MACT standards are promulgated, sources that must meet one of the MACT standards may not meet their legal requirements because sources that meet a different MACT standard might be over controlled. For example, a facility contains ten HON emission sources and ten plastic emission sources (similar to HON sources but to be regulated under a different MACT standard within the next five years). The facility uses all 20 sources in one emissions averaging program to meet the HON emission reduction requirements. Then later, when the plastics rule is promulgated, the facility will revise the emissions averaging program to insure emissions are reduced enough meet the emission reduction requirements of both the HON and plastics rules. But, if as a group the HON sources are over controlled and the plastics rule sources are under controlled, the concern is that the MACT requirements for the plastic sources is being violated.

The preamble provides an explanation as to why new sources were excluded from the program. New sources were excluded because historically they have been held to stricter standards than existing sources and it is most cost-effective to integrate state-of-the-art controls into equipment design and install the technology during construction. New sources are also required to meet stringent New Source Performance Standards (NSPS) under Title I.

The final rule limits the number of points that can be used in an emission averaging program whereas the proposed rule had no limit. According to the preamble, the EPA limited the program for two reasons. The concern of state and local regulators over the difficulty and resource burden of overseeing averages and the complexity of enforcing the emissions averaging program across large numbers of points could not be resolved. The EPA further rationalized its decision by stating that "most sources will not find a large number of opportunities to generate cost-effective credits. Hence, it can be anticipated that most averages will involve a limited number of emission points, and imposing a limit should not affect most sources."²⁹

The final rule only allows emissions credits for actions taken after November 15, 1990. In the preamble, the EPA states that actions taken before November 1990 were accomplished for reasons unrelated to the Amendments and thus constitute part of the baseline control of a source. The EPA concludes the emissions averaging section in the preamble with the statement the EPA still encourages the use of pollution prevention wherever feasible. The final HON rule also allows state and local regulators to disallow the emission averaging method of compliance and prohibits banking of credits for future years. Monitoring, recordkeeping, and reporting requirements are more rigorous than the RCT method of compliance.

Because the proposed emissions averaging program allowed averaging across all HAP's covered by the HON, there was considerable concern about the appropriateness of allowing interpollutant trading in an unrestricted manner. This concern was a common thread in the comments on the rule discussed earlier and in response the EPA rejected flexible compliance because of risk concerns.⁷ The EPA decided, in the final rule, to require sources to demonstrate their emissions averaging does not increase the risk in comparison to the required reference control technology. The EPA promises to provide a technical support document "to aid implementing agencies in making the demonstration based on existing procedures."

5.4 Future Direction for Pollution Prevention

The environmental community has become *very comfortable* in its ability to measure and predict the performance of end-of-pipe treatment technology. The reduction in quantity or quality of a waste as it passes through a treatment technology scenario can be easily measured, documented and defended under a permit-oriented system of environmental control. But this culture encourages and perpetuates the generation of pollution, not its reduction and prevention at the source. One of the leading impediments to the adoption of a pollution prevention system of environmental control is the inability to gain universal acceptance of a standardized process

which equates the results of pollution prevention/source reduction activities with the comfortable end-of-pipe treatment technologies. Ultimately the process must cause a culture change because success will be based on trust between ethical men and women, and flexibility in environmental law.⁵¹

The HON rule evolution provides a good example of how difficult it is to incorporate innovative, flexible ideas that encourage pollution prevention into regulations due in part to a lack of acceptable standardized processes. As originally envisioned, the emissions averaging program was to provide a flexible alternative to traditional end-of-pipe control technology. There were many provisions provided to encourage pollution prevention but no acceptable means to measure the progress, for example credit for early projects and broader scope options. The final rule, while still incorporating a scaled down emissions averaging program, is very limited in its flexibility and provisions for incorporating pollution prevention. This is particularly disheartening because the HON rule is considered to be the template for many future Title III regulations.

Fortunately, there is evidence the EPA is continuing towards its commitment to incorporate flexibility, innovation, and pollution prevention options within the regulations. The fact that the emissions averaging program was proposed and incorporated into the final rule is positive. Some of the smaller, more limited scope proposed and finalized MACT standards have incorporated innovative work practices as part of the regulations. (For example, see the Wood Furniture Finishing and Cleaning Operations rule.⁵²) Pollution prevention projects developed from the EPA Source Reduction Review Project (SRRP) are also being incorporated into the new Title III regulations. Because of the value of pollution prevention, and the need to incorporate innovative, flexible, pollution prevention options into regulations, the EPA is trying to develop new types of regulations instead of relying solely on end-of-pipe control technology.

Perhaps a simpler strategy to compliance is needed that would be easy to understand and adopt as part of the MACT standards. The strategy will still have to meet the same emission

reductions as the RCT but incorporate flexibility, innovation, and pollution prevention concepts.

The verifiability, enforceability and toxicity issues brought up by the emissions averaging program will have to be addressed.

VI. Netherlands Environmental Policy

6.1 Introduction

The Netherlands have an environmental policy that integrates a cross-media regulation approach with key environmental quality objectives with the goal of sustainable development in the country in one generation. The Netherlands environmental policy was studied with the hope of identifying new ideas to incorporate into the alternate compliance strategy. Section 6.2 provides a summary of the Netherlands policy and Section 6.3 discusses the policy advantages and limitations. Section 6.4 examines an effort to reduce data collection, the use of environmental management consultants and the value of program to the alternate compliance strategy.

6.2 Overview of Environmental Policy

In the mid-1980's, the Dutch decided traditional environmental protection measures, based on regulation of hazardous substances or processes, had largely failed in their small, densely populated, industrialized country. The quality of the Dutch environment was deteriorating and would continue to deteriorate unless radical changes were made. A national strategy for the environment entitled National Environmental Policy Plan (NEPP) was developed in 1989. The goal of NEPP was to achieve sustainable development in the Netherlands within one generation. The Dutch have quantified sustainable development to mean doubling the Dutch gross national product (GNP) by 2010 while achieving emission and waste discharge reductions of 70-90% (except CO₂). They plan to meet this goal through technological, social and economic change, supported by cooperative actions at the international level.

The NEPP establishes key environmental quality objectives, sets out a long term program of action, and acknowledges that a high quality environment cannot be achieved through

conventional pollution control measures alone.⁵³ A mixture of new, clean technologies, and structural changes in production and consumption patterns are also required. The Netherlands environmental policy uses a variety of voluntary and command-and-control programs to significantly reduce pollution. Specific pollution reduction requirements are set for different types of industries, however, flexibility is allowed in meeting the targets. In 1993, the second NEPP was implemented to strengthen the implementation of the program, required additional measures where objectives were not being met, and defined sustainable production and consumption.⁵⁴

The NEPP approach incorporates an integrated cross-media definition of the sources of environmental concerns. The key sources or target groups include agriculture, traffic and transportation, industry, energy supply and consumption, construction, and consumers. Pollution reduction objectives, or targets, are set for each target group in order for the Netherlands to reach its overall goal of sustainability by the year 2010. The targets specify pollutants to be reduced, quantity to be reduced, and timeline for meeting the target. Implementation of NEPP has focused on integration of environmental policy considerations into all sections of the Dutch ministries and local governments, and developing an open planning process with target groups. The planning process uses consultation and negotiation to develop agreements with members of target groups for voluntary reductions in emissions or implementation of environmental action plans.⁵⁵ The agreement specifies detailed goals, timetables, procedures, and respective responsibilities.

For example, the Declaration of Intent on the Implementation of Environmental Policy for the Chemical Industry was completed in April 1993.⁵⁵ The parties involved in negotiating the Declaration include the federal and provincial environmental regulatory offices, the Union of Netherlands Municipalities, the Association of Water Control Boards, the Association of Dutch Chemical Industry, and the individual chemical companies. A variety of pollution targets are described in the Declaration requiring significant reduction in CO₂, SO₂, NO_x, NH₃, VOCs, CFCs and related ozone depleters, and environmentally hazardous substances. For a specific

example, a 58% reduction in VOCs is required of the chemical industry by the year 2000 over the 1985 level of 28,000 tons. A reduction of 80% is required by 2010.

In order to meet these requirements, each company must develop and submit an environmental plan detailing how the requirements will be met. The companies can use their environmental plans to provide an integrated picture of the actions which they will take to meet the targets. "In doing so, companies will be able within certain limits to make their own decisions as to the nature and phasing of the measures to be adopted, a point of importance for the achievement of process-integrated solutions."⁵⁶ But according to the Declaration, companies must install Best Available Control Technology, at a minimum, as defined by the Dutch federal regulatory agency. The appropriate regulatory agencies review and approve the company environmental plans. These agencies can impose stricter conditions on the company if the proposed effort is deemed insufficient. Once the plan is approved, it becomes available for public inspection and is used by the regulatory agency to write the company's operating license. The license or permit covers all pollution media and all facility operations. The company must submit annual reports and an updated environmental plan every four years.

6.3 Advantages and Limitations

A recent article in *The EPA Journal* discussed four advantages of the NEPP.⁵⁷ First, with this system of agreements the company or regulated facility can set their own priorities in selecting the pollution control or prevention measures, as long as they can demonstrate they will be able to meet the required target goals. Companies are able to make optimal use of pollution prevention and resource saving measures specific to an individual facility and situation. Flexibility is realized because companies can combine investment in pollution prevention with equipment retrofits or facility replacement in order to meet the emission reduction requirements.

Second, regulatory agencies can use the company environmental plans to reduce the bureaucratic requirements of the permit-review process. Third, the agreement provides the company a measure of medium term security, because as long as the company is meeting the requirements of the agreement, no additional compliance requirements will be leveled against the facility. Finally, the agreement also provides the regulatory agency with a set of broad guidelines on how to appraise the individual facility.

Although the Netherlands environmental policy incorporates some interesting ideas, the Declarations of Intent from some of the target groups suggest many companies have not experienced the four advantages discussed above to the full extent suggested. The Declarations dictate in detail that the baseline requirements for the company environmental plans are the federal regulatory's Best Available Control Technology (BACT). This implies very limited flexibility in developing and implementing new pollution prevention technologies.

The Declaration of Intent for the Chemical Industry does discuss some pollution prevention possibilities. Under a section on additional requirements which will be forced on the chemical industry if implementing BACT is insufficient to meet the target goals, then "consideration may be given to investigate the possibility of developing or specifying supplementary technologies; these will in many cases consist of more advanced process-integrated solutions."⁵⁵ Advanced process-integrated solutions are a conceivable description of complex pollution prevention technologies. Under a section on waste disposal, the target goal for all chemical industry waste substances is to move from 60% disposal in 1986 to 89% prevention/recycling/useful applications. The target goal for 2010 is only 11% disposal. Throughout the NEPP, pollution prevention concepts are applied to waste disposal issues.

6.4 Additional Comments

An interesting tangent to the NEPP is the effort, since 1990, to reduce the quantity of environmental data collected and tailor it to the needs of the decision makers. The trend has been to reduce the number of monitoring points nationwide and to focus on those substances most important to human health and most easily monitored. Thirteen integrated monitoring stations (air, water, soil, flora and fauna) will soon be considered sufficient to provide a macro-picture of the Netherlands and to serve as an input to sophisticated environmental forecasting models. Monitoring priorities are shifting from monitoring effects to tracking socio-economic factors which drive the pollution processes, for example sales of new cars and trends in consumer spending. Biological indicators are used as evidence of environmental problems but have been downgraded as useful management tools.⁵³

An additional interesting aspect of the NEPP implementation strategy is the requirement for companies to pay for regional industrial environmental services (IES) and consulting firms. These IESs are responsible for providing the companies with advice on environmental management, regulatory requirements, and pollution control options. By 1995, a national network is to be built up comprising 30 to 40 IESs.⁵⁶

In conclusion, the Netherlands environmental policy appears to be more flexible and have a more cooperative, interactive philosophy than the United States program, but many portions of NEPP do not specifically encourage pollution prevention.

VII. Defining the Alternate Compliance Strategy

7.1 Introduction

Chapter 2 introduced and discussed the value of pollution prevention and Chapter 4 summarized three studies that indicated environmental regulations not only need to incorporate more pollution prevention concepts but also encourage innovative methods for pollution reduction. Since the HON rule is an ideal prototype to accomplish these changes, this chapter proposes an additional method of compliance based on pollution prevention concepts to be incorporated into the HON rule and other Title III regulations.

The chapter is divided into four sections. Section 7.2 discusses the general philosophy behind the alternate compliance strategy (ACS), and Section 7.3 defines the ACS. Section 7.4 discusses the significance of the ACS and how it will mesh with the HON requirements. Section 7.5 provides a summary.

7.2 General Philosophy

The goal of this research was to develop an alternate compliance strategy to end-of-pipe treatment for meeting environmental regulations in general. This new strategy goes further than current and proposed regulations to encourage pollution prevention, flexibility and innovation in all media. The strategy provides a means to further reduce emissions and risk to the environment while benefiting industry. It provides an example of the next step to take as regulations transition from end-of-pipe treatment to pollution management in the most efficient and effective method possible.

The alternate compliance strategy allows any regulated facility to determine its own performance standard based on the appropriate EPA regulation and then permit the facility to develop its own compliance program. The key difference is the facility determines the best

method of compliance for its situation, instead of the EPA dictating in detail how each facility must meet the regulations. The facility would have to reduce emissions of regulated hazardous air pollutants at least as much as the applicable statute requires. Innovation and pollution prevention will be encouraged directly by provisions that provide credit for emission reductions through pollution prevention programs and indirectly by providing flexibility and acceptance of alternative forms of compliance.

The proposed approach follows the historical progression from the command and control, end-of-pipe type of regulatory approach toward a more flexible, pollution prevention form of environmental management. Historically, the EPA has prescribed end-of-pipe standards to control pollution, accompanied with detailed instructions on every facet of pollution management. From the studies presented in Chapter 4, Regulatory Shortcomings, incorporating flexible, innovative performance standards would increase the use of pollution prevention. This proposed strategy provides a logical progression in the move toward pollution prevention and sustainable growth, by incorporating basic management concepts into compliance options.

The proposed strategy has the potential to not only benefit industry, but to also further reduce emissions and risk to the public and the environment. The Yorktown project, discussed earlier, provides a good example. When the project team developed the compliance plan for the regulated facility, the most cost effective plan possible was selected. At Yorktown, this was done by identifying ways to reduce overall pollution, not just some emissions. The optimum method of reducing or controlling emissions was evaluated instead of merely installing the reference control technology on major sources. Summarizing the results of the Yorktown project, the team recommended reducing about 7500 tons of emissions at a cost of \$500 per ton versus the CAAA regulations which required reduction of about 7300 tons of emissions at a cost of \$2400 per ton. The report indicated these emissions were not identical but similar. Many of the projects

identified by the team reduced overall facility emissions instead of many pollution control devices that merely transfer pollution from one media to another.

The proposed alternate compliance strategy (ACS) was developed to meet the requirements of the 1990 CAAA Title III standards. More specifically, the ACS will focus on the HON regulation because it is the first, major Title III regulation. Not only is the HON regulation current, it also includes the EPA's latest ideas on incorporating pollution prevention and flexibility into regulations. The HON regulation also covers a well defined regulated community; therefore, as this research effort demonstrates the effectiveness of the proposed strategy, a small set of examples of regulated facilities is used. Although, the proposed strategy is based on the HON regulation, the strategy concept is applicable to most other CAAA regulations and even the other media regulations.

7.3 The Alternate Compliance Strategy

The ACS was developed as an additional compliance method to RCT and emissions averaging in the HON regulation. The general requirements, applicability, and definitions of Subpart F and G apply.²⁹ It is recognized the specifics of regulation writing are difficult and complex. The proposed changes to the HON rule drafted in this section outline concepts that can be incorporated in the rule but may not meet the exact regulatory wording requirements.

In the HON rule, subpart §63.112 Emission standard, specifies the two compliance options available under the HON. The ACS requires a section be added with the proposed wording:

§63.112 (h) The owner or operator of a new or existing source may elect to calculate the required emission rate reduction specified in paragraph (a) and then develop and implement a program to reduce emissions to the calculated level.

The monitoring, performance test requirements, reporting and recordkeeping requirements of §63.113 through §63.148 will be met to the satisfaction of the responsible permitting authority for the various emission points (process vents, storage vessel, transfer operations, wastewater, and equipment leaks). The owner or operator shall also comply with the requirements of §63.151 Initial notification and Implementation plan and §63.152 General reporting and continuous records. The following two provisions are also provided:

(1) If any of the emission points have had their emissions reduced by a documented amount X since Jan 1, 1987 by a pollution prevention measure as defined by §63.150 (j)(1)(ii), actions taken under the Early Reduction Program, and/or measures implemented by voluntary participation in the EPA's 33/50 program, then the emission values for the respective emission points used in the emission rate reduction equation in paragraph (a) can be increased by $0.50X$. The 0.50 factor can be reduced if the emission reduction project only partially meets the §63.150 (j)(1)(ii) requirements.

(2) The owner or operator may elect to incorporate emission points into its compliance program that are not currently regulated under a Title III regulation. If a regulation is promulgated covering the unregulated sources, the required emissions reductions from each regulation must be met for the respective regulated emission points.

7.4 The Significance of the Proposed Alternate Compliance Strategy

The proposed addition of the ACS to the HON regulation requires the same emission reduction as the RCT and emissions averaging (EA) form of compliance. The ACS concept is simple but the impact on those regulated by the rule is profound. What follows is a detailed

discussion of the difference between ACS and the two compliance methods under the HON rule and the implications of those differences. Table III provides a summary.

Table III. Comparing the ACS to the Existing HON Rule

Requirements	HON Rule	ACS
Required Emission Rate Reduction Equation	Not required for RCT, required for EA.	Required.
Types of Sources	New & existing for RCT and existing for EA.	New & existing.
Emission Points	All regulated points for RCT. Limited to 20 or 25 points with EA & no credit for biological wastewater treatment or equipment leaks.	All regulated points.
Compliance	Well defined, incorporating monitoring, engineering assessment, paperwork, etc.	Same as HON rule but recommends changes to expedite approval of new ideas.
Monitoring	Defined by Group. Some flexibility required for EA.	Same as HON rule but some flexibility required.
Performance Test	Defined by Group. Some flexibility required for EA.	Same as HON rule but some flexibility required.
Specific Reporting & Recordkeeping	Defined by Group. Some flexibility required for EA.	Same as HON rule but some flexibility required.
General Reporting	Four types of reports. Increased requirements for EA.	Same as HON rule. Recommend submitting Implementation Plan early.
Credit for Pollution Prevention	Indirect for RCT. EA gives credit for projects after Nov 1990.	Credit for 50% of emission reduction for projects after Jan 1987.
Broadening of Source Definition	Not permitted.	Permitted for any emission point not currently regulated under Title III.

7.4.1 Required Emission Rate Reduction

The required emission rate reduction specified in paragraph (a) of §63.112 of the final HON rule is shown in Equation 1.²⁹

$$E_A = 0.02 \times \Sigma EPV_1 + \Sigma EPV_2 + 0.05 \times \Sigma ES_1 + \Sigma ES_2 + 0.02 \times \Sigma ETR_1 + \Sigma ETR_2 + \Sigma EWW_{1c} + \Sigma EWW_2$$

Equation 1

Where:	E_A	=	Emission rate, megagrams per year, allowed for the source.
	$0.02 \Sigma EPV_1$	=	Sum of the residual emissions, megagrams per year, from all Group 1 process vents.
	ΣEPV_2	=	Sum of the emissions, megagrams per year, from all Group 2 process vents.
	$0.05 \Sigma ES_1$	=	Sum of the residual emissions, megagrams per year, from all Group 1 storage vessels.
	ΣES_2	=	Sum of the emissions, megagrams per year, from all Group 2 storage vessels.
	$0.02 \Sigma ETR_1$	=	Sum of the residual emissions, megagrams per year, from all Group 1 transfer racks.
	ΣETR_2	=	Sum of the emissions, megagrams per year, from all Group 2 transfer racks.
	ΣEWW_{1c}	=	Sum of the residual emissions from all Group 1 wastewater streams.
	ΣEWW_2	=	Sum of emissions from all Group 2 wastewater streams. ²⁹

In the HON regulation, Equation 1 is used to calculate the allowable emission rate of organic HAP's for new and existing sources subject to the requirements of Subpart G. Facilities using only the RCT method of compliance need not calculate the allowable emission rate, but can merely install the RCT on all Group 1 emission points. The equation was developed for the emissions averaging compliance method but is also appropriate for the ACS. The emissions values in Equation 1 can be determined from equations in §63.150 Emissions Averaging Provisions. The equations are complex, and require considerable information about emission points that may not be readily available.

7.4.2 New and/or Existing Sources

The RCT compliance method covers both new and existing sources, with new sources more tightly regulated. The emission averaging program can only be used on existing sources. The ACS can be used on both new and existing sources. The foremost reason for extending the

ACS to new sources is because the best opportunity to incorporate new ideas for pollution prevention or reduction is during the design and construction of new equipment.

The ACS encourages companies to try new ideas because, if the final emission reduction does not quite meet the RCT percent reduction required, then the company can reduce emissions elsewhere in the facility by the necessary amount. Compare this to the RCT where the company either installs the specified control devices or initiates a lengthy review process. If the company obtains the necessary approval to proceed with the new idea but when constructed the ideas fall short of the expected emissions reduction, then the company must install the expensive RCT control devices anyway or attempt to negotiate a compliance program under the emissions averaging compliance program.

Attempting to calculate the required emission rate reduction for a new source presents a dilemma. The emission rate values needed for the equation in §63.112 (a), (also equation 1, in Section 7.4.1) represents what the new facility would have emitted if built using RCT and modern equipment but without any innovative, pollution prevention projects the facility may want to implement. This emission baseline of what the new facility would emit is difficult to estimate and justify, but under the current regulatory framework it is the only alternative. Further research is needed to develop alternatives. For the ACS, it is suggested that reasonable values can be obtained from a similar MACT facility. It is likely that any company preparing to build a new facility or make a major modification will have existing similar modern facilities that can be used to estimate the reasonable emission rates from a similar new facility. Contingency provisions should be part of the ACS compliance program in case the new innovative, pollution prevention projects are not as effective as expected. The permitting agency will verify the validity of the emissions values used.

7.4.3 Emission Points

The HON rule contains RCT provisions for the following emission points: process vents, storage vessels, transfer operations, and wastewater processes. Emissions averaging can only be used on a few points and may not be used on equipment leaks or wastewater streams that are treated in a biological treatment unit. The wastewater streams can not be used in emissions averaging because of the concern over the difficulty of accurately determining emissions reduction. Averaging of equipment leaks is not permitted, in part for the same reason, but also because they are in a separate special negotiated subpart of the HON.

The ACS is designed to be used on any and all emission points. Removing the limitations increases flexibility and encourages industry to develop accurate methods of emission reduction because compliance with the necessary emission reduction is still required. Industry will have to demonstrate to the permitting agency's satisfaction that the HAP emissions are being reduced to the extent required. The methods available to demonstrate compliance are discussed in the next section.

7.4.4 Demonstrating Compliance

If a facility elects to meet the HON requirements using the RCT method, then compliance is straight forward. The control devices must be installed, operated, monitored correctly, and the necessary paperwork completed. But if the ACS or emissions averaging is used, demonstrating compliance is more difficult. First, the required emission rate reduction must be calculated using Equation 1 for the regulated facility. Then a strategy must be designed to meet the required emission reduction and compliance must be demonstrated. The compliance strategy must be comprehensive and well documented enough to convince the permitting agency of the adequacy of the proposed program. Designing the strategy and convincing the permitting agency

may be difficult because of the uniqueness of pollution prevention measures and other related issues discussed in Section 2.5.

The HON rule contains specific and general provisions that can be used to demonstrate compliance for innovative projects. Subpart §63.150 (j) provides procedures for calculating the efficiency (% reduction) of pollution prevention measures.²⁹ The owner or operator will have to work closely with the permitting agency when determining these values to insure acceptance.

The EPA permits a variety of methods to demonstrate compliance; the most obvious is measuring the actual HAP emissions. An engineering assessment can be used in lieu of measuring, which includes using previous representative test results, bench-scale or pilot-scale test data, value limits specified or implied within an applicable permit (for example, maximum flow rate or total organic carbon emission rate), or design analysis based on accepted engineering principles. Examples of accepted engineering principles include: use of material balances based on process stoichiometry to estimate maximum organic HAP concentrations or estimation of maximum flow rate based on physical equipment design such as pump or blower capacities.²⁹

In numerous locations within the regulation, paragraphs are provided for gaining approval for use of alternative measures. For example, §63.121 Storage Vessel Provisions, covers alternative means of emission limitations requirements. This subpart details the procedures to receive a determination of equivalence for an alternative measure to the control measures detailed in the regulation. The owner or operator must collect, verify, and submit specific information about the proposed alternative measure to the EPA Administrator for review and acceptance. By regulation, the EPA has 120 days to determine whether sufficient information has been submitted, and an additional 120 days after sufficient information has been submitted to approve or disapprove the new technology. The EPA will then publish a notice in the Federal Register. These provisions sound beneficial but, historically, getting an approval from the EPA has been

very slow, laborious, and required extensive information. For the ACS to be usable, the acceptance procedure for new ideas or alternative measures must be simplified.

The final HON rule has an interesting provision for attempting to approve new control technologies in the emissions averaging section, §63.150 (i). More specifically the provision is written for establishing nominal efficiencies for control technologies that are different in use or design from the RCT and achieve greater percent reductions than the percent efficiencies assigned to the RCT. If the owner or operator is only going to use this new control technology for less than four applications at a single plant site, then approval can be made at the permitting authority (state or local environmental agency authorized by the EPA to implement the requirements of the regulation) instead of the EPA Administrator. When reviewing the application, if the permitting authority believes the new control technology has broad applicability for use by other sources, then the permitting agency submits the information to the Administrator for review. The Administrator review will not affect the permitting agency's approval of the nominal efficiency of the control technology for the specific application.

This provision for approving new technologies should be expanded to all new ideas with no limit on applications to include: pollution prevention projects, monitoring approaches, and other innovative projects. The facility could submit the documentation for the new projects to the permitting agency during permit application or Implementation Plan submission, discussed below. The permitting agency could approve, disapprove the new idea or project, or request additional information. The facility could move forward, with some expediency towards compliance without waiting for the EPA Administrator's approval. If the permitting agency felt the project or idea had wide spread application, they would submit the documentation to the EPA Administrator. If the EPA Administrator determined the new project or idea to be of a different efficiency than the permitting agency approved, then adjustments would be made at the next permit renewal of the facility.

7.4.5 Monitoring Requirements

The HON rule has specific monitoring requirements for the different types of emission points. The requirements are extensive for Group 1 emission points (significant HAP emitters) and typically have two levels of requirements for the Group 2 emission points (relatively insignificant HAP emitters). The first level of Group 2 requirements is for the Group 2 emissions points that are close to Group 1 in HAP emission levels. The second level of requirements is for those points emitting very minute amounts of HAPS. The monitoring requirements also vary depending on the specific type of control devices used on the emission point. Although the regulation is designed around the RCT, the requirements can be met by the ACS if some latitude is permitted.

The emissions averaging compliance method requires the facility to meet the RCT monitoring requirements. If no applicable monitoring parameters or inspection procedures are specified, then the owner or operator submits documentation to justify and explain their proposed monitoring plan as part of the Implementation Plan.

An example of the structure of the monitoring requirements and the limitation for use with the ACS is demonstrated under the sections for process vents. Process vent requirements are broken into three groups, delineated by the vent's total resource effectiveness index value (TRE). The TRE index is a "measure of the supplemental total resource requirement per unit reduction of organic HAP associated with a process vent stream, based on vent stream flow rate, emission rate of organic HAP, net heating value, and corrosion properties", as quantified by the equations given under §63.115.²⁹ The three groups are process vents with a TRE value less than one (Group 1); and Group 2 process vents with either a TRE index value between 1 and 4 or a TRE value greater than 4.

The monitoring requirements are more stringent for the Group 1 process vents because they emit a greater volume and/or concentration of HAPs and are tailored for the specific RCT

applied. To summarize the requirements, if an incinerator is used, then a temperature monitoring device equipped with a continuous recorder is required. If a flare is used, then a device capable of continuously detecting the presence of a pilot flame is required, and for a boiler or process heater a temperature monitoring device in the firebox equipped with a continuous recorder is required.

The next set of requirements are for the Group 2 process vents, with a TRE index value between 1 and 4, that use one or more product recovery devices. These vents are required to have either an organic monitoring device equipped with a continuous recorder or specific monitoring equipment. An example of the latter is where an absorber is the final recovery device in the recovery system, a scrubbing liquid temperature monitoring device and a specific gravity monitoring device, each equipped with a continuous recorder is required. The HON regulation has no monitoring requirements for Group 2 process vents with a TRE index greater than 4.

There is one additional provision where an owner or operator may request approval to monitor different parameters than those specified. The request must be properly documented and is only valid if used for a different control device, a different recovery device (only if the TRE index is between 1 and 4), and if listed equipment is being used but the owner or operator wishes to monitor a different parameter.

It is conceivable that a facility using the ACS or the emissions averaging method could develop a compliance program that does not fit any of these scenarios. For example, a Group 1 process vent with a pollution prevention measure used instead of the RCT. Under these circumstances, the owner or operator would have to develop the monitoring program, in consultation with the permitting agency, to approximate as closely as possible the requirements detailed in the regulation.

The provisions for monitoring of transfer operations are very similar to the process vent requirements. The ACS can be integrated with these requirements in a manner similar to the

example provided on process vents. The HON monitoring requirements for storage tanks and wastewater operations are flexible enough to be used directly by the ACS because there are provisions for alternate methods of compliance.

7.4.6 Performance Test Requirements

The structure of the performance test requirements are similar to that of the monitoring requirements. The requirements are specific for different types of equipment and are segregated for Group 1 and 2 emission points. Provisions are provided for alternative approaches that might be a part of an ACS compliance program for most emission points. For example, §63.117 which describes the requirements for process vents performance tests includes provisions for a facility that uses control or recovery devices not specifically addressed.²⁹ The section requires the owner or operator to submit a description of planned reporting and recordkeeping procedures as part of the Implementation Plan. There are no such provisions for alternate approaches for transfer operations. The owner or operator using the ACS on a transfer operation would have to develop appropriate performance test requirements in coordination with the permitting agency. The ACS can comply with the rest of the performance test requirements as currently written.

7.4.7 Emission Point Specific Reporting and Recordkeeping Requirements

The HON reporting and recordkeeping requirements have a similar structure to the monitoring requirements. The ACS can meet the storage tank requirements, although some latitude would be required on the other types of emission points. For example, in the wastewater process section there are provisions for meeting the reporting and recordkeeping requirements for new or alternative control devices other than the RCT. But, there are no provisions for pollution prevention measures or other innovative approaches. Latitude would have to be permitted for a facility using an ACS option on a Group 1 wastewater process. The permitting

agency would have to work with the facility to decide on mutually acceptable reporting and recordkeeping requirements.

7.4.8 General Reporting

The HON rule requires a regulated facility to prepare and submit four types of reports: the Initial Notification, Implementation Plan, Notification of Compliance Status, and Periodic and Other Reports. The Initial Notification is due 120 days after the rule promulgation for existing sources. New sources must submit an application for approval of construction as soon as practicable before construction. The Initial Notification must include a list of the regulated chemical manufacturing process units in the facility, and which of the HON rule provisions will apply (process vents, transfer operations, etc.) A detailed identification of emission points is not necessary, however a statement must be included of whether the facility can achieve compliance by the specified compliance date (compliance required by Apr 97 for existing sources or at start up for new sources).

The Implementation Plan details how a facility will comply with the HON requirements and is not required if an operating permit application (under Title V) has been submitted. The operating permit will have similar requirements. For existing sources, the Implementation Plan must be submitted 12 months prior to date of compliance unless emissions averaging is being used as part of the compliance program. The Implementation Plan for the emission points incorporated in the emissions averaging must be submitted 18 months prior to date of compliance.

The extra six months is required to allow time for the EPA Administrator to review the Plan, request additional information or request changes to the Plan, and for the owner or operator to respond. The Implementation Plan must include: an identification of the chemical manufacturing processes, a list of all regulated emission points including whether each point is Group 1 or 2, and the specific control technique, pollution prevention method, or planned method of compliance

to be used. A supplement must be included to justify and explain any alternative controls or operating scenarios that may be used to achieve compliance. The plan must also state that appropriate testing, monitoring, reporting, and recordkeeping will be accomplished. If a facility uses the emissions averaging option, then additional information is required including: the projected credit or debit generated by each point; and the overall expected credits and debits. The facility must also complete all testing, monitoring, reporting and recordkeeping for all Group 2 points used in the average as if they were Group 1 points. If an owner or operator wishes to monitor a unique parameter or use a unique recordkeeping and reporting system, the request, including a rationale, must be submitted with the Implementation Plan.

The Notification of Compliance Status reports must be submitted within 150 days after the required compliance date. It must contain information on Group 1 points and all points in emissions average necessary to demonstrate achieving compliance. The notification must include: results of performance tests for emission points, one complete test report for each test method used for a particular kind of emission point, TRE determinations for process vents, design analyses for storage vessels and wastewater emission points, site-specific ranges for each monitored parameter for each emission point and the rationale for the range, and values of all parameters used to calculate emission credits and debits for emissions averaging.

Periodic and other reports are those required under the specific report requirements of each emission point and the emission averaging program. Quarterly and/or semiannual reports are required for the emissions averaging credit/debit system, and for parameter values for emission points outside the established range. Examples of other reports include: start-up, shutdown, and malfunction reports; and notifications of inspection for storage vessels.

The ACS can meet all the report requirements. To the extent possible, a facility using ACS should follow the requirements for a facility using the RCT method of compliance. Two exceptions are suggested. First, pollution prevention projects or other innovative projects or

ideas should be well documented and explained to facilitate acceptance by the permitting agency. Second, the Implementation Plan should be submitted 18 months prior to the compliance date to allow sufficient time for review, information transfer, and explanation for the permitting agency to understand and accept the new ideas. The facility using the ACS should not be required to follow the emission averaging reporting requirements, because of the dramatic increase in recordkeeping and reporting requirements. If the permitting agency requires additional information on a pollution prevention project on a specific Group 2 emission point, then the requirement can be incorporated in the Implementation Plan.

Most facilities will not complete these reports directly because the permitting authority (typically the state environmental regulatory agency) will incorporate the HON requirements within the state Title V permitting program. The information required in the state permit application and compliance program will be similar to the HON requirements discussed here but the exact format will be determined by the state permit program.

7.4.9 Provision 1: Pollution Prevention Projects

The first provision of the ACS will reward past accomplishments in pollution prevention and participation in the environmentally beneficial EPA voluntary programs. The reward will further encourage future innovative projects and ideas, particularly if the provision is incorporated in all future Title III regulations.

As discussed in Section 5.2, the concept of Provision 1 originated in the emissions averaging program in the proposed HON rule. The concept of giving credit for pollution prevention measures initiated after January 1, 1987, actions initiated under the Early Reduction Program, and/or measures implemented in voluntary participation of the EPA's 33/50 program, was removed from the final rule because of the concern that industry would not be forced to reduce HAP pollution as much as possible. If pollution prevention and other innovative ideas are

to be the future of environmental management they must be overtly rewarded or industry will cease to invest in pollution prevention research and incorporating pollution prevention projects. As an attempt at compromise, a 50% factor is incorporated into the provision. This factor can be reduced if the emission reduction project only partially meets the requirements of pollution prevention.

A simple example is provided to illustrate the use of this provision. Assume, in 1985, a chemical manufacturing facility emits 100 megagrams (110 tons) per year of benzene. For simplicity, the facility has only process vents, and storage tanks, both Group 1 and 2. Table IV lists the original benzene emissions, in megagrams/yr, under the column 1985, for the various emission points. In 1988, an inline recycling pollution prevention project was installed in the facility that significantly reduced the benzene from several of the process vents and storage tanks. Table IV lists the benzene emissions after the pollution prevention project in the column 1988. The emission rate values in column 1988 are the values that a facility would be required to use for the emissions averaging program because the project was implemented prior to November 1990 (the cut-off date for pollution prevention credit in the final HON rule). If the facility chose to use the RCT method of compliance, then the specified control devices would be required on all Group 1 emission points. The final column in Table IV demonstrates the emission calculation using Provision 1. The actual 1995 emissions are used plus 50% of the emission reduction from the pollution prevention project.

Table V illustrates the impact of Provision 1 on the allowed emission rate for the source (Equation 1). E_{A85} is the allowed emission rate from the final HON rule if the facility had not implemented the pollution prevention project. The 22.8 megagrams/yr is the maximum amount of benzene the facility could emit, for both RCT and emissions averaging compliance methods, and still be in compliance with the HON requirements. E_{A88} is the allowed emission rate after implementation of the pollution prevention project for both the RCT and emissions averaging

Table IV. Calculating Emissions using Provision 1

Types of Emissions	1985 megagrams/yr	1988 megagrams/yr	Provision 1 megagrams/yr
ΣEPV_1	40	10	$10 + (0.5 \times 30) = 25$
ΣEPV_2	10	5	$5 + (0.5 \times 5) = 7.5$
ΣES_1	40	30	$30 + (0.5 \times 10) = 35$
ΣES_2	10	10	10
Total	100	55	77.5

compliance method. Note, the facility must reduce its emissions of benzene more (from 22 megagrams/yr to 16.7 megagrams/yr) because the pollution prevention project was implemented. E_{API} is the allowed emission rate using the ACS Provision 1 which provides partial (50%) credit for the implemented pollution prevention project. Although compliance with the HON requires significant reduction in emissions for all three scenarios, the Provision 1 overtly encourages pollution prevention.

Table V. Allowable HAP Emissions Illustrating Provision 1

Components of Equation 1	E_{A85} megagrams/yr	E_{A88} megagrams/yr	E_{API} megagrams/yr
$0.02 \Sigma EPV_1$	$0.02 \times 40 = 0.8$	$0.02 \times 10 = 0.2$	$0.02 \times 25 = 0.5$
ΣEPV_2	10	5	7.5
$0.05 \Sigma ES_1$	$0.05 \times 40 = 2.0$	$0.05 \times 30 = 1.5$	$0.05 \times 35 = 1.75$
ΣES_2	10	10	10
Total	22.8	16.7	19.75

7.4.10 Provision 2: Emission Points from Unregulated Sources

The purpose of this provision is to encourage owners or operators to incorporate other sources into their HON ACS program. This concept was proposed as an alternative in the

proposed HON emission averaging program, as discussed in Section 5.2. The EPA suggested three benefits from this concept: reduced compliance cost for the same emissions reduction, more stringent future MACT standards, and control of undiscovered emission points. The concept, of permitting regulated facilities to incorporate emission points into its compliance program that are not currently regulated under a Title III regulation, will also increase flexibility and could encourage more expansive pollution prevention projects.

The concept, of allowing unregulated emission points to be included into the compliance program, was not included in the final HON rule because the EPA concluded that as future MACT standards were promulgated, the proposed EPA program could not guarantee all emission reductions for each standard would be met. This provision incorporates the requirement that should a regulation be promulgated covering the unregulated sources, the required emissions reductions from each regulation must be met by the respective regulated emission points.

Provision 2 will increase flexibility because some MACT standards will not be promulgated for several years. As new standards are promulgated, any regulated facility will have to evaluate its compliance status with regards to the new requirements. This provision is a first step towards more facility-wide compliance programs instead of the piece-meal regulation approach currently used.

7.5 Summary

The proposed ACS is a method to incorporate pollution prevention and other innovative ideas into the HON and other similar Title III regulations. The ACS transforms existing language in the HON rule into a performance standard that a regulated facility can use to calculate its allowed HAP emission rate. The regulated facility can then design a compliance plan to meet that rate. In general, the ACS can meet the HON requirements by incorporating the same emission reductions, and similar monitoring, performance testing, and reporting requirements.

The ACS encourages innovation and pollution prevention by permitting flexibility in meet emission reduction requirements. The ACS also includes two provisions; one to reward past pollution prevention efforts and therefore encourage new, and the second to expand the scope of the pollution prevention effort within the facility.

VIII. Criteria for Strategy Evaluation and Methods to Measure Performance

8.1 Introduction

The ACS is evaluated and compared to the two methods of compliance under the HON in Chapter 12. The evaluation is based on the example application of the ACS to a baseline facility in Chapter 11. Two types of evaluation methods are developed, qualitative and quantitative, to evaluate the ACS. The qualitative evaluation compares the ACS to the compliance methods under the HON rule using criteria derived from the Title III statutory requirements and the concerns of interested parties. The concerns of interested parties were developed from information presented in Section 3.7, Comments on the HON Rule, and Chapter 5, The HON Rule Evolution. In Section 8.2.3, an Evaluation Matrix, listing the 12 criteria, is shown to compare the ACS to the RCT and emissions averaging methods of compliance.

The quantitative evaluation methods include the application of the total cost assessment model and the risk reduction measurement model. The total cost assessment model is presented in Section 8.2. The development and application of the risk reduction measurement model is discussed in Chapter 9.

8.2 Criteria for the Evaluation Matrix

8.2.1 Compatibility with 1990 CAAA and HON Regulation

The first criteria for evaluation is compatibility with the relevant statutes and regulations. The general requirements of both were outlined in Chapter 3, Clean Air Act Amendments Summary, and Chapter 7, Defining the Alternate Compliance Strategy. This limitation on the compliance strategy is being used in order to facilitate possible incorporation, as an alternative method of compliance, within the existing HON regulation and future MACT standards.

8.2.2 *Concerns of Interested Parties*

The compliance strategy must attempt to address the issues of interested parties including environmental groups, state and local regulators, regulated community, and the EPA. These concerns are assimilated from the comment summaries on the proposed HON rule, in Chapter 3, and the analysis of the HON evolution in Chapter 5. Additional ideas, from an article by Thomas McGarity, are also summarized.⁵⁸

Environmental groups are concerned with protecting human health and the environment. They want regulations as strict as possible to insure the regulated industries are reducing emissions. These groups are interested in implementability, verifiability, and enforceability issues. Additionally, environmental groups want flexibility limited in order to close "loopholes" for industry and they want more pollution control, monitoring, and reporting.

State and local regulators want simple, implementable, enforceable, verifiable regulations which do not completely inundate their workload. They want regulations that mesh with their existing regulatory structure and affords them flexibility in implementing the requirements. These regulators are concerned with their cost of implementation and the quantity of paperwork associated with regulations. They are concerned with legal defensibility, protection of human health, and incorporation of the latest control and monitoring technology.

Industry is concerned with the impact of the regulation on their profitability. They are concerned about the high cost of compliance - capital costs for emission control, monitoring, and recordkeeping equipment; maintenance and operation costs; and administrative costs. They want a regulation that contains as few requirements as possible; is flexible, understandable and simple; and permits innovation and change. The regulated community is concerned whether the regulation is fair to all parties and that compliance is attainable, for example, the technology exists to meet the standards. They are interested in a method for dealing with overlapping and conflicting regulatory requirements.

The EPA attempts to develop regulations that are timely, efficient, and flexible in achieving the maximum degree of emission reductions practicable. They want the regulations to be implementable, verifiable, and enforceable, but also encourage pollution prevention and innovative solutions. The EPA strives to promote pollution prevention related research and protect human health through risk reduction. The EPA is concerned whether the regulation is legally defensible and administratively accomplishable. The EPA is also sensitive to the impact of these regulations on industry and works with industry to develop workable, cost effective rules.

Additional input was found in an article entitled "*Media-Quality, Technology, and Cost-Benefit Balancing Strategies for Health and Environmental Regulation*,".⁵⁸ Six evaluation criteria for regulations are listed:

1. Efficiency - lowest cost to achieve desired goals. Often called cost-effectiveness analysis.
2. Administrative feasibility - the practical implementability of the regulatory program.
3. Enforceability - specific, measurable requirements, and punishments for violations.
4. Survivability - ability to survive judicial and political review. Judicial review is the ability for the regulation to withstand legal challenges. Political review is the ability of the regulation to satisfy the relevant Congressional committees, the President, and other influential political bodies.
5. Equity - requirements are applied fairly to the entire regulated community. For example, the requirements for new versus existing facilities.
6. Technological advancement - ability of the regulation to force or encourage the advancement of technological research.

8.2.3 Evaluation Matrix

Table VI lists the twelve evaluation criteria from the concerns of interested parties in a matrix that permits comparison between the HON compliance methods and the ACS. The twelve

criteria include the six from McGarity and include an additional six from the comment summaries and HON evolution analysis. The meaning for each criteria is summarized below. During the evaluation, in Chapter 12, the three compliance methods will each be given a score between 0-10 for each criteria - ten being optimum. Although the score may be partially subjective, justification is provided for the scores and comparison made. Some of the criteria may have different interpretations depending on which outlook is considered. An average score is given.

Table VI. Evaluation Matrix

Criteria	HON RCT	HON Emissions Averaging	ACS
1. Meets Statutory Requirements			
2. Protect Human Health			
3. Implementability			
4. Enforceability			
5. Flexibility			
6. Simplicity			
7. Administrative Impact			
8. Cost			
9. Legal Survivability			
10. Technology Advancement			
11. Encourages Pollution Prevention			
12. Fairness to Sources			

1. Meet Statutory Requirements, is the ability of the compliance method to meet the defined MACT standard.
2. Protect Human Health, is the propensity of the compliance method to reduce risk to the workplace and local community.
3. Implementability, has different interpretations depending on which outlook is considered. Implementable to a regulator means ability to incorporate within

existing programs and implement with a minimum of additional resources. Implementable to a regulated facility means the compliance method is understandable, doable, and compliance is attainable.

4. Enforceability, is the ability for the compliance method to verify that necessary emissions reductions have been accomplished and facilitate the levying of punishments for noncompliance.
5. Flexibility, for the regulator, implies the ability to incorporate the new compliance method within existing programs, work with regulated facilities to develop mutually agreeable compliance strategies, and incorporate new and/or unusual technology requirements with in the compliance program. Flexibility to industry means the ability to develop a compliance strategy that allows the individual facility to change processes and operations as necessary to meet consumer requirements with a minimum of regulatory impediments.
6. Simplicity, is a relative comparison between the three compliance methods.
7. Administrative Impact, is the quantity of paperwork and data, and its subsequent evaluation required by the compliance method. The impact will vary depending on the viewpoint taken.
8. Cost, means the cost of compliance to the regulated facility and the cost to implement and enforce to the regulator.
9. Legal Survivability, both judicial and political review, was defined above.
10. Technology Advancement, is the ability of the compliance method to force or encourage, and incorporate new, innovative methods of reducing, controlling and monitoring pollutants.
11. Encourage Pollution Prevention is the ability of the compliance method to encourage, reward, and adopt pollution prevention concepts and methods within the compliance program.
12. Fairness to Sources, is the equity by which the requirements are levied against the various regulated facilities - new versus old, small versus large, etc.

8.3 Total Cost Assessment Model

8.3.1 Introduction

The financial/economic evaluation method used to compare the ACS with the compliance methods in the HON rule is Total Cost Assessment (TCA). This EPA program was discussed

in Section 2.3 as a comprehensive, long-term financial analysis of pollution prevention projects and other more traditional projects. TCA is used to evaluate pollution prevention projects and other options by using environmental data, appropriate time horizons, and standard financial indicators. TCA can be a key component in a company's capital budgeting system that facilitates reasonable comparison between pollution prevention initiatives, and other capital projects or pollution control options.⁵⁹

8.3.2 Tailored Overview of the Total Cost Assessment Process

Using TCA for economic analysis of compliance options contains four elements: (1) extended cost inventory, (2) cost allocation, (3) time horizon, and (4) long-term financial indicators. Each element is discussed below with the primary focus on extended cost inventory which details the various types of data required to complete a thorough TCA. Long-term financial indicators are the numerical values used to compare environmental compliance options. A tiered analysis is discussed as an efficient method of applying TCA to a given situation. Types of data are collected in a sequential manner starting with the simplest to collect. The financial indicators are calculated and the compliance methods compared.

8.3.2.1 Extended Cost Inventory The extended cost inventory identifies costs and savings associated with compliance options. This inventory goes further than conventional project financial analysis which generally limits evaluation to the most obvious, direct, and tangible capital and operation costs and savings. A list of potential TCA costs and benefits is shown in Table VII.^{60,11}

Direct costs can usually be identified and quantified through traditional data sources. Indirect costs refer to regulatory compliance costs that are typically lumped into a general or "overhead" account. Other indirect costs include costs that are identified and recorded in the

Table VII. Potential Total Cost Assessment Costs and Benefits

1. Direct Costs			
•	Capital expenditures		
••	Buildings		
••	Equipment		
••	Utility connections		
••	Equipment installation		
••	Project engineering		
•	Operation & maintenance expenses/revenues		
••	Raw materials		
••	Labor		
••	Waste disposal		
••	Utilities: water, sewer, energy		
••	Recovered material revenue		
2. Indirect or Hidden Costs			
•	Compliance costs		
••	Permitting	••	Reporting
••	Tracking	••	Monitoring
••	Manifesting	••	Training
••	Waste handling	••	Recordkeeping
••	Labeling	••	Testing
••	Spill prevention	••	Medical oversight
•	Waste storage		
•	Operation of on-site pollution control equipment		
•	Raw materials linked to nonproduct output		
•	Environmental insurance		
3. Liability Costs			
•	Penalties and fines		
•	Legal claims for personal injury and property damage		
4. Less Tangible Benefits			
•	Increased revenue from enhanced product quality		
•	Increased revenue from enhanced company and product image		
•	Reduced worker compensation and absenteeism costs from improved employee health		
•	Increased productivity from improved employee relations		
•	Reduced staff burdens in dealing with community concerns		
Sources: White, USEPA "Total Cost Assessment"			

accounting system but are not typically used in capital budgeting. Indirect costs may play an essential role in the financial analysis of pollution prevention investments due to the high cost of environmental compliance.⁵⁹

Liability costs are associated with liabilities that may result from material and waste management. Because the goal of pollution prevention is to reduce or eliminate pollution, the

savings from lower liabilities could provide significant benefits that might otherwise be ignored. Liability costs are difficult to quantify because they are obscure to estimate and difficult to locate at a point in the lifecycle of a project. Several methods have been implemented for accounting for liability costs. Some companies have chosen to ease the financial performance requirements (for example, raising the required payback period from 3 to 4 years, or lowering the required internal rate of return from 10 to 8 percent) of the pollution prevention project to account for liability reductions.⁴ Liability costs can be estimated by multiplying the estimated probability of occurrence by the estimated cost of liability. The estimated probabilities and costs can be approximated from reviewing plant experience related to environmental liabilities, reviewing environmental liabilities occurring at other plants within the company or industry, or forecasting future liability based on past experience.⁵⁹

While indirect and liability costs can be difficult to quantify, less tangible benefits are even more troublesome, but should still be considered in the analysis. Pollution prevention projects may deliver substantial benefits from an improved product, company image, and employee health. Although some attempts have been made to quantify these benefits, a qualitative analysis may be more appropriate.

8.3.2.2 Time Horizon The second element in TCA is a longer time horizon than traditional cost analysis, because certain costs and savings from pollution prevention take many years to materialize. Traditional profit investment analysis often confines costs and savings to two to five years whereas effective application of TCA requires extending the time horizon to five or more years in order to evaluate the very costs and savings that TCA is designed to capture. A ten to fifteen year horizon is recommended for capturing out-year liability costs, waste avoidance savings, and revenue growth linked to market development of environmentally friendly products.

8.3.2.3 Long-term Financial Indicators The third element in TCA is project assessment tools to compare projects for capital budgeting. Long-term financial indicators must meet two criteria: (1) ability to incorporate all cash flows (positive and negative) over the life of the project; and (2) utilize the time value of money through appropriate discounting of future cash flows. The Net Present Value (NPV), Internal Rate of Return (IRR), and Profitability Indicator (PI) methods meet both criteria and are defined below. The NPV method is preferred because there are certain conditions under which the IRR or PI methods fail to identify the most advantageous project.^{60,11}

Net Present Value (NPV) The present value of each cash flow, both inflows and outflows, is calculated and discounted at the project's cost of capital. The NPV is the sum of the project's discounted cash flows. The project with the highest positive NPV is the best economic investment. Other factors, such as the initial capital investment and the length of the project, may also be considered in the investment decision.

Internal Rate of Return (IRR) Calculates the discount rate that equates the present value of a project's expected cash inflows to the present value of the project's expected costs. A project is a good investment when the calculated IRR is greater than the cost of capital to finance the project.

Profitability Index (PI) Known as the benefit/cost ratio. The PI is the present value of benefits divided by the present value of costs, and shows the relative profitability of a project. The best investment is the project with the highest positive PI.

8.3.2.4 Cost Allocation The fourth element of TCA is cost allocation or full-cost accounting which is invaluable to sound investment profitability analysis. Costs for waste management, regulatory compliance, and pollution control must be allocated to appropriate processes in a manner that reflects the way the costs are actually incurred. Traditional cost allocation incorporates these costs into "overhead" accounts.

8.3.2.5 Tiered Analysis System Most examples of using TCA, in the literature, use all four elements of TCA and attempt to evaluate all costs and benefits in the extended cost inventory.^{61,60,11} The end result of the TCA analysis is a summary that lists the costs and benefits incorporated into the analysis and the calculated financial indicators for each option. The main limitation to evaluating all the costs and benefits at the start of a TCA analysis is that some of the extended cost data is difficult to obtain and the analysis may be completed using the readily available information but not necessarily the best information. A more efficient method of analysis is suggested by the EPA "Pollution Prevention Benefits Manual"⁶² which recommends a tiered analysis approach to limit the TCA analysis to only the information that is necessary. The TCA tiered analysis starts with the direct costs, tier 1, that are typically the most accessible. After calculating the long-term financial indicators of the economic viability of the various projects, the process either stops or continues depending on whether the analysis indicates the pollution prevention project or projects may meet the investment criteria of the organization.

If necessary, the indirect costs, tier 2, are incorporated into the TCA and again the financial indicators are calculated. Tier 3, liability costs and tier 4, less tangible benefits or costs can also be incorporated. Financial calculations for each tier are completed one tier at a time, permitting an evaluation between all projects being analyzed at each tier. The decision to continue the TCA analysis to the next tier is determined by comparing the time and cost to gather the necessary data versus the potential value to be gained from the more encompassing financial

indicators.¹¹ For example, an inexpensive pollution control project is being compared to an expensive pollution prevention project to meet a regulatory requirement. If only tier 1 is used in the TCA analysis, then the financial indicators favor the pollution control device. But if the pollution control project will require an expensive modification to the wastewater treatment facility at the plant, whereas the pollution prevention project will reduce the load on the wastewater treatment facility, then incorporating tier 2 into the TCA may indicate the pollution prevention project is more beneficial for the company.

8.3.3 Application of Total Cost Assessment to the Alternate Compliance Strategy

TCA is used in this research to provide an economic and financial analysis of compliance options, specifically compliance using the HON rule compliance methods and the ACS. TCA is designed to provide a more equitable analysis of pollution prevention projects than is possible when only using traditional financial analysis.

The tiered analysis method is used to make the cost/benefit data collection and calculation as efficient as possible. Although the TCA tiered analysis system process sounds tedious, it is reasonably simple to set up using typical personal computer spreadsheet programs. Costs for the tiers are added as necessary and the spreadsheet software is used to calculate the long-term financial indicators: NPV, IRR, and PI. This process is used in this research to compare financial ramifications associated with the HON compliance methods versus the ACS in Chapter 12. The difficulty is in determining reasonable values for the expanded cost inventory. A time horizon of ten years is used to be consistent with TCA guidelines. The need for proper cost allocation is documented in the final analysis.

IX. Risk Reduction Measurement Model

9.1 Introduction

In Section 3.2, the historic evolution of the regulation of HAPs was discussed. Initial HAP regulations were risk-based because of the concern for protecting human health from toxic pollutants. The risk-based regulations were troublesome for the EPA to promulgate because of the difficulty of meeting the ample margin of safety statute requirement. Title III of the 1990 CAAA was crafted by relying on a technology-based standard to avoid the risk issue and allow the EPA to promulgate regulations for the HAPs. The Title III statute includes a requirement that the EPA evaluate residual risk eight or nine years after regulation is promulgated.

The continuing concern from interested parties over risk was evident in the comment summaries, Section 3.7. Although the EPA was directed in the statute to promulgate regulations using only available control technology as a basis, public concern over risk caused the EPA to address the risk issue on the newly proposed emissions averaging method of compliance because emissions averaging was more flexible than the control technology based RCT requirements. The HON rule requires a risk evaluation from a regulated facility to demonstrate that the use of the emissions averaging method of compliance will not increase risk over the RCT method of compliance.

The ACS is more flexible and encompassing than the emissions averaging program, therefore the risk to the community must be addressed to be a viable method of compliance under the Title III requirements. A fairly simple, comprehensive method to evaluate risk from pollution prevention options is needed to insure they are as protective of human health and the environment as traditional end-of-pipe control technology. This risk evaluation is needed to facilitate the acceptance of pollution prevention as an alternative to control technology in regulations.

Unfortunately, risk assessment is a complex and continually evolving field and sufficient data is rarely available to answer all questions.

The development of a model to evaluate the magnitude of the change in risk to communities surrounding a facility releasing air pollutants is presented. The model is useful in evaluating the risk associated with various alternate compliance options by estimating the magnitude of the change in risk from changes in the quantities and/or types of pollutants released. Change in risk, or relative comparable risk, is evaluated because less data is required to estimate the change in risk when a control technology, or pollution prevention project is used, than to accomplish thorough, definitive risk assessments. The proposed model estimates the magnitude of the change because with the assumptions necessary for the model simplifications, the risk values estimated may be significantly different than values that might be determined in a more thorough risk assessment. However, the change in risk from the model will be representative of the change in risk of a more thorough risk assessment.

This chapter is divided into five sections. Section 9.2 provides a summary of the risk assessment process used by the EPA; and Section 9.3 details the risk reduction measurement model development. Section 9.4 discusses chemical comparison issues that can only be partially resolved. Section 9.5 provides three examples using the Risk Reduction Measurement Model. Section 9.6 discusses additional considerations which are not incorporated into the model; i.e. emissions sources besides process vents and chemical mixtures, and provides a summary.

9.2 Risk Assessment Summary

9.2.1 Introduction

Risk assessment is a procedure used by the EPA to estimate the potential adverse health effects (current or future) caused by hazardous substance releases from a facility or site.⁶³

Complete risk assessments are often complex and many of the individual steps can be difficult to accomplish. The risk assessment concepts can be applied to simplified situations using basic equations and/or software programs. Risk assessment contains four steps: hazard identification, dose-response assessment, exposure assessment, and risk characterization. Each step is summarized in the subsequent four subsections.

9.2.2 Hazard Identification

The first step in risk assessment, hazard identification, is to evaluate whether a chemical, pollutant, or agent is hazardous to people. More specifically, the goal of hazard identification is to identify the types of adverse human health effects that can be caused by exposure to a chemical, and to assess the quality and weight of evidence supporting this identification. Hazard identification involves review and evaluation of various types of experimental and other reported information for the purpose of identifying the nature of the hazards associated with a chemical.⁶⁴ The resulting information is then used to determine if the chemical causes toxic effects. A toxic response to a chemical is exemplified by three types of experimental data: "(1) quantal responses, in which the number of responding individuals in a population increased; (2) dose-graded responses, in which the severity of the toxic response in an individual increase with dose; and (3) continuous responses, in which changes in a biological parameter vary with dose".⁶⁵

When available, human studies are given first priority when evaluating a chemical. Such information is usually not available and the hazard identification must usually rely on animal studies with extrapolations required from the animals to humans. Many factors are potentially evaluated when determining the weight of evidence for a chemical, including: similar results in replicated animal studies by different investigators; similar effects across sex, strain, species, and exposure route; evidence of a dose-response relationship; plausible relationship between data on metabolism, postulated mechanism-of-action, and the effect of concern; similar toxicity exhibited

by structurally related compounds; and evidence of the postulated chemical effect of concern on humans. The current EPA weight of evidence classification for carcinogens is shown in Table VIII. (The weight of evidence of a chemical will be outlined like A for clarity). The EPA is considering a new weight of evidence system that would use only (1) likely or known, (2) cannot be determined, or (3) not likely as the categories for chemicals.⁶⁶

Table VIII. EPA Categorization of the Weight of Evidence of Carcinogenicity Based on Animal and Human Data

Human Evidence	Animal Evidence				
	Sufficient	Limited	Inadequate	No Data	No Evidence
Sufficient	A	A	A	A	A
Limited	B1	B1	B1	B1	B1
Inadequate	B2	C	D	D	D
No Data	B2	C	D	D	E
No Evidence	B2	C	D	D	E

Source: USEPA, "Risk Assessment Course Documents,".

Where:

Group A:	Human carcinogen
Group B:	Probable human carcinogen.
	B1 indicates that limited human data are available.
	B2 indicates sufficient evidence in animals and insufficient evidence in humans.
Group C:	Possible human carcinogen
Group D:	Not classifiable as to human carcinogenicity.
Group E:	Evidence of noncarcinogenicity for humans.

9.2.3 Dose-Response Assessment

The second step in the risk assessment process, requires identifying the observed quantitative relationship between dose and response, and extrapolating from the conditions of exposure for which data exist to other conditions of interest. This step usually consists of high-to-low dose extrapolation and frequently involves extrapolating animal data to humans.⁶⁴

Empirical observations have generally revealed that as the dosage of a toxicant is increased, the toxic response (in terms of severity and/or incidence of effect) also increases. This dose-response relationship is well-founded in the theory and practice of toxicology. Many difficulties arise in accurately determining the dose-response relationship, including defining the response or effect, determining interspecies extrapolation or concordance, and determining the optimum dose(s). An optimum dose is a dose that will not kill the animal outright, but elicit a cancerous response. Because so little usable human epidemiological data is available, the majority of information gathered about possible chemical toxicity comes from animal experiments. Typically, rats and mice are used in toxicological experiments. Fifty animals per sex are usually required for a control group and for each dosage level considered. Animals are exposed to the chemical for a predetermined amount of time ranging from a few days up to their entire lives and their bodies are examined at study completion for tumors and other clinical/toxicological effects.

Following toxicological and/or epidemiological studies, chemicals are typically classified as being carcinogenic (or suspected) or lacking evidence of carcinogenicity but possessing systemic noncarcinogenic effects. Carcinogenicity has traditionally received greater weight. The classification determines how the risk assessment is conducted.

Carcinogenesis, unlike noncarcinogenic health effects, has generally been evaluated based on the presumption of a no threshold hypothesis. The theory holds that a small number of molecular events can evoke changes in a single cell that can lead to uncontrolled cellular proliferation and eventually to cancer. Carcinogenesis is referred to as "nonthreshold" because there is believed to be essentially no safe or risk-free level of exposure to such a chemical that does not pose a finite probability of generating a carcinogenic response. For carcinogenic effects, EPA uses a two-part evaluation in which the substance first is assigned a weight-of-evidence classification, and then a dose-response slope factor is calculated if sufficient data is available.⁶³

Recent data is collected and compared with the data used to determine the weight-of-evidence classification in step 1. If sufficient data is available to suggest carcinogenicity, the chemical is given a classification from Table VIII of Group A, B1, B2 or C. In the second part of the evaluation, the slope factor (SF) (a toxicity value that defines quantitatively the relationship between dose and response) is calculated. The slope factor is used in risk assessments to estimate an upper-bound lifetime probability of an individual developing cancer above a background level as a result of exposure to a particular dose of a potential carcinogen.

Slope factors are derived from the most appropriate data set(s) available with order of preference being high quality human data, low quality human data, animal data from a species physiologically similar to humans, and finally animal data from the most sensitive species. Occasionally, multiple studies are used. A mathematical model is used to extrapolate from the high doses used in studies to the lower exposure levels expected in the environment. A variety of mathematical models and procedures have been developed, but the EPA has traditionally used the linearized multistage model which is considered to be conservative, in the absence of adequate information that a different model is more appropriate. The linearized multistage model is considered to be conservative. After the data are fit to the appropriate model, the upper 95th percent confidence limit of the slope of the resulting dose-response curve is calculated. This value is known as the slope factor and represents an upper 95th percent confidence limit on the probability of a response per unit intake of a chemical over a lifetime. If the slope factor was determined using animal data, equivalent human doses are determined using surface area and body weight ratios raised to a power.⁶³

Evaluation of chemicals considered to have significant noncarcinogenic effects is different than carcinogenic chemicals because noncarcinogenic chemical effects are assumed to have a threshold. A threshold level implies that for an individual, a dose level exists below which an adverse response is unlikely; because homeostatic, compensation, and adaptive mechanisms in

the cell protect against toxic effects. The individual threshold hypothesis holds that some exposures can be tolerated by an organism with essentially no chance for expression of a toxic effect.

A reference dose (RfD) is defined as an estimate (with uncertainty spanning an order of magnitude or greater in some cases) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.⁶³ Most common is the chronic RfD, specifically developed to be protective for long-term exposures, but EPA also develops subchronic (short-term exposure) and developmental (babies and children) RfDs. RfDs are usually derived for oral exposures to chemicals, although some dermal RfDs are available. Inhalation reference concentrations (RfCs) are determined for inhalation exposures.

The first step in determining the RfD is a survey of available data. As with the carcinogenic chemicals, quality human data is preferred but rarely available. Animal data is typically used with an emphasis on relevance and scientific quality of the experimental studies. When possible, the EPA selects studies done with species that are relevant to humans based on defensible biological rationale, i.e., using comparative metabolic and pharmacokinetic data. Once the study (or studies) is selected, a no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) is determined.

NOAEL is defined as the highest experimental dose of a chemical at which there is no statistically or biologically significant increase in frequency or severity of an adverse effect in individuals in an exposed group when compared with individuals in an appropriate control group. Determining an adverse versus a not adverse effect can be difficult to demarcate.

An RfD is derived from the NOAEL (or LOAEL) by use of uncertainty factors (UF) and a modifying factor (MF). Uncertainty factors are generally multiples of 10, and are listed in Table IX with the modifying factor.⁶⁷ The RfD for a chemical is calculated from Equation 2.

Table IX. Description of Uncertainty and Modifying Factors

<u>Uncertainty Factors</u>	<u>General Guidelines</u>
H	Interhuman. A 10-fold factor is used when extrapolating from valid experimental results from studies using prolonged exposure to average healthy humans. Intended to account for the variation on sensitivity among members of the human population.
A	Experimental Animal to Human. For RfDs, a 10-fold factor is used when extrapolating from valid results of long-term studies on experimental animals when results of studies of human exposure are not available or are inadequate. For RfCs, a 3-fold factor is used. Intended to account for the uncertainty in extrapolating animal data to humans.
S	Subchronic to Chronic. A 10-fold factor is used when extrapolating from less than chronic results on experimental animals or humans. Intended to account for the uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs.
L	LOAEL to NOAEL. A 10-fold factor is used when deriving an RfD from a LOAEL. Intended to account for the uncertainty in extrapolating from LOAELs to NOAELs.
D	Incomplete Database. A 10-fold factor is used when extrapolating from valid results in experimental animals when the data is incomplete. Intended to account for the inability of any single study to adequately address all possible adverse outcomes.
MF	Modifying Factor. An additional uncertainty factor, determined through professional judgment, where $0 < MF \leq 10$. The factor depends on the professional assessment of scientific uncertainties of the study and database not explicitly treated above. The default value is 1.
Source: Dourson	

$$RfD = \frac{NOAEL \text{ or } LOAEL}{(\prod_{i=0}^n UF_i) \times MF} \quad \text{Equation 2}$$

Where: $\prod_{i=0}^n UF_i$ - All of the appropriate UFs multiplied together.

9.2.4 Exposure Assessment

Exposure assessment, the third risk assessment step, is the identification of the conditions of exposure of the human population group that might be at risk and for which protection is sought. Exposure is defined as the contact of a human with a chemical measured by intensity, frequency, and duration.⁶⁴ The exposure assessment process consists of three phases: characterize setting, identify pathways, and quantify exposure.

Characterization of the exposure setting requires evaluating general physical site characteristics and characteristics of the local populations around the area of interest. Important site characteristics can include: climate, wind patterns, topography, vegetation, ground-water hydrology, and surface water. Local populations are identified and described with respect to characteristics influencing exposure, such as location relative to the area of interest, activity patterns, and the presence of sensitive subpopulations.

In the second phase, possible exposure pathways are determined by which the identified populations may be exposed. Exposure pathways are distinguished based on consideration of the sources, releases, types, and locations of chemicals at the site; the likely environmental fate of these chemicals; and location and activities of the potentially exposed populations. Evaluating the fate and transport of the chemical in the release media often involves a complex analysis. Issues include various types of transportation (i.e. water and wind); the outcomes of physical, chemical, and biological transformations (i.e. precipitation, photolysis, and biodegradation, respectively); and accumulation of the chemical in various media. Points of potential contact, exposure points, and exposure routes (i.e. ingestion, inhalation, and dermal exposure) are identified.

In the third phase, exposure quantification, the magnitude, frequency, and duration of exposure for each pathway is quantified. Initially, the concentration of chemicals to which the populations are exposed are determined over the exposure period. Exposure concentrations are estimated using monitoring data and/or chemical transport and environmental fate models. Modeling may be used to estimate future chemical concentrations in media that are or may become contaminated, and current concentrations in media at locations where no monitoring data exists.

Once the chemical concentrations are determined, the potential intakes by the people can be estimated. Chemical intakes are calculated using equations that include variables for exposure

concentration, contact rate, exposure frequency, exposure duration, body weight, and exposure averaging time. Chemical-specific exposures are calculated for each exposure pathway. For example, the equation for inhalation intake can be calculated using the following equation and associated values from the EPA's Risk Assessment course documents.

$$Intake = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT} \quad \text{Equation 3}$$

Where:

<i>Intake</i>	-	Exposure concentration, amount of contaminant at the body exchange boundary (mg of contaminant/kg body weight-day)
<i>CA</i>	-	Contaminant concentration in air (mg/m ³)
<i>IR</i>	-	Inhalation or contact rate (m ³ /hr)
<i>ET</i>	-	Exposure time (hr/day)
<i>EF</i>	-	Exposure frequency (days/yr)
<i>ED</i>	-	Exposure duration (yrs)
<i>BW</i>	-	Body weight (kg)
<i>AT</i>	-	Averaging time (days)

Typical values:

<i>IR</i>	=	0.83 (m ³ /hr) for an adult
<i>ET</i>	=	24 (hr/day)
<i>EF</i>	=	360 (days/yr)
<i>ED</i>	=	70 or 30 (yrs)
<i>BW</i>	=	70 (kg) for an average adult
<i>AT</i>	=	Appropriate days/yr * 70 yrs for carcinogens

Finally, the sources of uncertainty and their possible effect on the exposure estimates are evaluated and summarized. Sources of uncertainty can include, but are not limited to: variability in analytical data, modeling results, and parameter assumptions.⁶³

9.2.5 Risk Characterization

For the final step of risk assessment, the information on hazard identification, dose-response, and exposure assessment are used to derive qualitative and quantitative expressions of risk. Risk characterization is accomplished in four phases: (1) organize outputs of exposure and toxicity assessments, (2) quantify pathway risks for each substance, (3) combine risks across pathways, and (4) assess and document uncertainty. The risk characterization is accomplished differently for carcinogenic versus noncarcinogenic chemicals. To characterize potential

carcinogenic effects, probabilities an individual will develop cancer over a lifetime of exposure are estimated from projected intakes and chemical-specific dose-response information. To characterize potential noncarcinogenic effects, comparisons are made between projected intakes of substances and toxicity values for adverse effects.

The first phase, organize outputs of exposure and toxicity assessments, requires summarizing the necessary information from the dose-response and exposure assessments for each pathway. The consistency and validity of key assumptions common to the exposure outputs are verified and the toxicity outputs for each contaminant and exposure pathway are reviewed. Important issues include using the correct averaging period for exposures, ensuring all possible exposure routes have been evaluated, and making absorption adjustments when appropriate.

The second phase requires quantifying the pathway risks for each substance. For noncarcinogenic chemicals, the hazard quotient, the ratio of the exposure intake to a reference concentration, is calculated. For carcinogenic chemicals, risk is calculated according to the following linear low-dose cancer risk equation.⁶³ Risk is a unitless probability an individual will develop cancer from exposure to the chemical. EPA considers values below 1×10^{-6} to be acceptable.

$$Risk = CDI \times SF \quad \text{Equation 4}$$

Where: CDI - Chronic daily intake averaged over 70 years (mg/(kg-day)).
 SF - Slope factor, expressed in (mg/kg-day)⁻¹

When working with air borne chemicals, an inhalation unit risk (IUR) is often calculated from the following equation.

$$IUR = \frac{(SF \times IR \times 10^{-3})}{BW} \quad \text{Equation 5}$$

Where: IUR - Risk per $\mu\text{g}/\text{m}^3$
 SF - Slope factor (mg/kg-day)⁻¹
 IR - Inhalation rate of 20 m³/day
 BW - Body weight of 70 kg

Because the slope factor is usually an upper 95th percentile confidence limit of the probability of response based on experimental animal data, the carcinogenic risk estimate will generally be an upper-bound estimate. The EPA is reasonably confident that the "true risk" will not exceed the risk estimate derived through use of this model and is likely to be less than predicted. Risk assessment experts stress that calculated risk values are conservative estimates and must be treated as such.

For noncarcinogenic chemicals, the potential for adverse effects is calculated from Equation 6. The potential for noncarcinogenic effects is not expressed as the probability of an individual suffering an adverse effect because there is a lower bound threshold. The noncancer hazard quotient (*HQ*) is the ratio of a single substance exposure level over a specified time period to a reference dose for that substance derived from a similar exposure period. If *HQ* is unity or less, then the EPA considers the exposure level to be below the threshold level and unlikely to cause adverse health effects. The greater the *HQ* value, the more increased the concern for potential noncancer adverse effects.

$$HQ = \frac{E}{RfD} \quad \text{Equation 6}$$

Where: *E* - Exposure level or intake. *E* and *RfD* (or *RfC*) are expressed in the same units and represent the same exposure period.

For the third phase, risks are summed for all chemicals and combined across pathways. Often during risk assessments, more than one chemical must be evaluated for potential health effects. In general, all the cancer risk values are summed to determine the total cancer risk and all the noncancer hazard quotients are summed to determine a hazard index. This conservative approach is arguable. For example, a risk assessment evaluates the potential hazard of four noncarcinogenic chemicals each of which is associated with very different effects on the human body. If the *HQ* for each chemical was less than one but the hazard index was three, it may not be reasonable to state that the exposures are too high to be protective of human health. It may

not be logical to add *HQs* if the effects from the chemicals are not related. The EPA also recognizes that summing does not account for possible synergistic or antagonistic chemical relationships, but very little information is available on these relationships. The risks are also combined across exposure pathways by identifying reasonable exposure pathway combinations and evaluating whether it is likely that the same individuals would consistently face the calculated intakes by more than one pathway.

The fourth and final phase is the assessment and documentation of assumptions, uncertainties, and scientific judgements. This phase is crucial in developing a framework to define the significance of the calculated risks. The documentation is a summary used to specify the assumptions and uncertainties inherent in the risk assessment in order to place the risk estimates in proper perspective. Information is included on important site-specific uncertainty factors; model assumptions; fate, transport, and exposure parameter uncertainties; and toxicity assessment uncertainty factors.

9.3 Development of A Model for Evaluating Risk Reduction

9.3.1 Introduction

The purpose of this model is to evaluate the magnitude of change in risk to communities resulting from changes in the quantities of chemicals and/or changes in the types of chemicals released. The model is useful in evaluating the risk associated with various alternative compliance options. Although this method was developed assuming the facility of interest is regulated under Title III of 1990 CAAA, it is applicable to different and more general applications.

The method development follows the four risk assessment steps discussed in Section 8.2. The results are equations that provide either change in risk ($\Delta Risk$) for carcinogenic chemicals, or change in hazard quotient (ΔHQ) for noncarcinogenic chemicals for two different chemical

emission rates. Numerous chemicals can be evaluated. This method has limitations; it evaluates relative change in risk (or hazard quotient) not actual risk to the communities around a facility; where possible, procedures are simplified; and the values given are order of magnitude estimates. The method does not attempt to evaluate the issues the EPA has chosen not to evaluate for lack of information, for example: multi-chemical interactions, and chemical transformation in the environment.

9.3.2 Hazard Identification and Dose-Response Assessment

The first step is to determine whether a chemical is hazardous. This step is completed for the purpose of the model development, because the 189 hazardous air pollutants (HAPs) regulated under Title III have, by definition, been designated as hazardous. Various quantities of epidemiological and toxicological data are available for the 189 HAPs.

The second step requires identifying the observed quantitative relationship between exposure and response, and extrapolating from the conditions of exposure for which data exist to other conditions of interest. For the majority of the 189 HAPs, slope factors (*SF*) for carcinogenic effects and/or inhalation reference concentrations (*RfC*) for noncarcinogenic effects have been estimated by the EPA. These values are available in EPA's Integrated Risk Information System (IRIS) or from the Health Effects Assessment Summary Tables (HEAST) issued quarterly by the EPA. A few of the HAPs have not been sufficiently researched for the EPA to estimate a *SF* and/or *RfC*. Additional information about chemicals not evaluated sufficiently to be included in IRIS or HEAST, can be obtained from existing EPA Health and Environmental Effects Documents (HEEDs), Health and Environmental Effects Profiles (HEEPs), and Reportable Quantity documents.⁶⁸ The EPA is no longer preparing the HEEDs, HEEP, or Reportable documents, therefore additional information will have to be obtained through literature searches and/or contacting appropriate EPA people.

9.3.3 Exposure Assessment

The third step is identification of the conditions of exposure to the human population that might be at risk and consists of three phases: characterize exposure setting, identify exposure pathways, and quantify exposure.

9.3.3.1 Characterize Exposure Setting Characterizing exposure setting is not necessary for this risk reduction evaluation method because the facility, the general physical characteristics around the facility, and the characteristics of the populations around the facility are constant. The method evaluates the change in magnitude of the risk not the actual risk, therefore specific information to characterize the setting is not required.

9.3.3.2 Identify Exposure Pathways With HAPs, the obvious exposure pathway of concern is inhalation. Potential pathways, besides inhalation, include ingestion of contaminated water, food, or soil, and dermal contact with contaminated water, soil, and other materials.

For a complete risk assessment of air emissions for a particular site, total risk (*TR*), for carcinogenic chemicals is calculated:

$$TR = InhR + IngR + DerR \quad \text{Equation 7}$$

Where:

<i>TR</i>	-	Total risk from all carcinogenic chemicals through all exposure pathways.
<i>InhR</i>	-	Risk from inhalation from all carcinogenic chemicals.
<i>IngR</i>	-	Risk from ingestion from all carcinogenic chemicals. Exposure pathways can include: ingestion of contaminated water, soil, fish, and meat, dairy, fruits and vegetables.
<i>DerR</i>	-	Risk from dermal exposure from all carcinogenic chemicals. Exposure pathways can include: skin exposure to contaminated water while swimming and showering, and to contaminated soil.

Total Hazard Index, for noncarcinogenic chemicals, could be calculated in a similar manner.

Several studies have been conducted on evaluating the impact of different exposure pathways from air pollutants and have determined inhalation and ingestion pathways to be

significant, depending on the site specific characteristics. For example, the Electric Power Research Institute (EPRI) developed a methodology to estimate multimedia health risks associated with power plant emissions.⁶⁹ This multimedia model treats the fate and transport of chemicals in the atmosphere, surface water, vadose zone, groundwater, and foodchain. The EPRI model is used to calculate the individual and population exposure, as well as the associated health effects. The model was applied to four geographically and operationally different fossil-fueled power plants where 19 chemicals were analyzed; 13 metals, 2 inorganic gases, 3 organic gases, and polynuclear aromatic hydrocarbons (PAHs). The exposure pathways evaluated from the air emissions were inhalation, ingestion, and dermal absorption.

The study concluded that inhalation was the dominate pathway in two of the four sites, while ingestion was dominate in the other two. The dominate pathways were directly related to the local conditions (i.e., a nearby lake used for fishing, swimming, drinking or land used for agricultural or recreational purposes) and to the nature of the individual chemicals; persistence, bioaccumulation, vapor pressure, etc.

Calculation of ingestion and dermal exposure is very site specific. For example, determining exposure from contaminated vegetables requires estimating the type and percentage of contaminated vegetables consumed and the concentration of pollutant in the vegetable from deposition and uptake from the roots. These values are soil and plant specific. The EPA provides guidance and equations for estimating exposure levels for various scenarios of ingestion and dermal chemical exposures.⁷⁰

For the proposed risk reduction model, total risk is not required, merely the magnitude of change in risk due to a change in concentration from the source. As is discussed in the Section 9.3.3.3, the change in inhalation risk can be estimated using a simple linear equation. A simple linear equation can not be developed for other types of risk without site specific information. It is reasonable that a drop in concentration of air pollutants would equate to a

decrease in exposure from the other exposure routes although the decrease would not be as immediate as with inhalation. For the risk reduction measurement model, only the change in inhalation risk will be used as an indicator of change in total risk. Ignoring ingestion and dermal exposure may be insignificant for application to the chemicals regulated by the HON rule, because the majority are volatile organic chemicals. Volatile organic chemicals are more likely to be an inhalation hazard than ingestion or dermal exposure hazard due to their low deposition rate. Metal air pollutants and semi-volatile chemicals are primarily bound to particulate matter which have a higher likelihood of deposition and accumulation onto land and water.⁷¹

9.3.3.3 Quantify Exposure Quantifying exposure requires estimating the frequency, duration, and magnitude of exposure for each chemical and pathway. To be conservative and simple, frequency is assumed to be continuous and duration is assumed to be the life of the person - 70 years.

Estimating the magnitude of exposure is not simple. A conservative value for the concentration level for any given HAP for the person most at risk must be estimated. The concentration of a chemical of interest coming out the stack is assumed to be known. The person most at risk will be directly downwind, living as close to the facility as possible (at the facility fence line). A chemical concentration value this person might experience can be directly measured or estimated using any of the many dispersion and transport modeling equations or software programs.

Given the simplicity of the scenario outlined in the previous paragraph, an appropriate model, developed by D. Bruce Turner, is used. Equation 8, developed from three references on dispersion modeling, provides the ground level concentration at a distance x directly downwind from the source.^{72,73,74}

$$C_x = \frac{Q}{\pi \times \sigma_y \times \sigma_z \times u} \exp \left[-\frac{1}{2} \left(\frac{H}{\sigma_z} \right)^2 \right] \quad \text{Equation 8}$$

Where:	C_x	-	Ground level concentration at some distance x downwind (mg/m ³)
	Q	-	Average emission rate (mg/sec)
	u	-	Mean wind speed (m/sec)
	H	-	Effective stack height (m)
	σ_y	-	Standard deviation of wind direction in the horizontal (m)
	σ_z	-	Standard deviation of wind direction in the vertical (m)

A value of 200 meters was used for x because the EPA routinely uses this value as a conservative fence line assumption.^{75,76} H was assumed to be 10 meters to be consistent with the EPA; the value was not adjusted for effective height of emission because of the small value of x .⁷² Values of u , σ_y , and σ_z were combined to determine the maximum value of C_x . The desired value was obtained for E stability class and a u of 1 m/sec.⁷⁴ This represents an overcast night with very little wind. When these values are used:

$$C_x = Q \times (1.3 \times 10^{-3}) \quad \text{Equation 9}$$

A summary of assumptions used in Turner's model development includes:

1. Steady state emission from the source so that diffusion in the direction of transport is neglected.
2. The pollutant is a stable gas or aerosol which remains suspended in the air over long periods of time.
3. None of the pollutant is removed from the plume as it moves downwind and there is complete reflection at the ground.
4. The mean wind speed is in the x direction and representative of the diffusing layer.
5. In general, the plume constituents are distributed normally in both the cross-wind and vertical directions.⁷²

These assumptions are common to most dispersion models, because without them the model equations become very complex.⁷² With the hazardous organic chemicals used in this scenario, the second assumption is suspect because organic chemicals are usually not considered stable. But, since the mean wind speed $\mu = 1$ m/sec is used and the distance to the closest potential person is 200 meters, the time between the pollutant leaving the stack and reaching the

closest person is only 200 sec. According to Seinfeld, degradation of organic chemicals at 200 min is approximately zero therefore this assumption is valid.⁷⁷ Some dispersion models also incorporate gas density of the pollutant to account for the tendency of volatile pollutants to rise. Not using a gas density correction is conservative. Many of the complex modeling programs incorporate terrain, weather, and other specific information which is not required because the result of using the risk reduction measurement model is change in risk, not actual risk. For example, because change in risk is evaluated, the terrain is constant and although weather does change, the model calculates concentration directly downwind, and weather will not differ appreciably between source and person.

Maximum exposure intake can now be estimated by substituting the maximum ground level concentration, C_x , from Equation 9 into Equation 3. Using the typical values defined for calculating *Intake* in Equation 3, Equation 10 can be derived.

$$MEI = Q \times (4 \times 10^{-4}) \quad \text{Equation 10}$$

Where: MEI - Maximum exposure intake (mg/kg-day)
 Q - Average emission rate of the chemical of interest (mg/sec)

9.3.4 Risk Characterization

In the fourth and final step, the information and values determined in the previous three steps are combined to estimate the risk associated with the chemical of interest. An upper bound estimate for risk is calculated for carcinogenic chemicals by multiplying the chemical slope factor (SF) times the maximum exposure intake from Equation 10. The result is shown in Equation 11. The hazard quotient (HQ) for noncarcinogenic chemicals is calculated by dividing the maximum exposure intake from Equation 10 by the chemical reference dose (RfD). This result is shown in Equation 12.

$$Risk = Q \times (4 \times 10^{-4}) \times SF \quad \text{Equation 11}$$

$$Hazard\ Quotient = \frac{Q \times (4 \times 10^{-4})}{RfD} \quad \text{Equation 12}$$

When dealing with inhalation exposures, the EPA recommends using reference concentrations (*RfC*) to calculate *HQs*.⁷⁸ Current methods for derivation of *RfCs* include addressing the dynamics of the respiratory systems and its diversity across species and the differences in the physicochemical properties of contaminants.⁷⁹ Prior to January 1991, the EPA used inhalation Reference Doses (*RfDi*). A *RfDi* can be converted to a *RfC* using Equation 13, but the EPA warns this conversion maybe technically incorrect because Equation 13 is based on a body weight, inhalation rate ratio instead of a thorough evaluation of the absorption rate, and the metabolic, pharmacokinetic impact of the HAP on the respiratory system.^{78,65} Equation 12 can be converted to *RfC* using Equation 13, giving Equation 14. Equation 14 states that for the given units the *HQ* is equal to *Q* divided by *RfC*, all other factors cancel out with the unit conversions.

$$RfC = \frac{RfDi \times BW \times 10^3}{IR} \quad \text{Equation 13}$$

$$Hazard\ Quotient = \frac{Q \times 1}{RfC} \quad \text{Equation 14}$$

Where:

<i>SF</i>	-	Slope factor, (mg/kg-day) ⁻¹
<i>RfD</i>	-	Reference dose (mg/kg-day)
<i>RfC</i>	-	Reference concentration (μg/m ³)
<i>IR</i>	-	Inhalation rate of 20 m ³ /day
<i>BW</i>	-	Body weight of 70 kg

Equation 13 does not imply a *RfD* can be directly converted to a *RfC* in all situations or vis-a-versa. If a specific *RfD* is determined from chemical ingestion data (oral route of exposure or other route), using it to derive a *RfC* introduces additional uncertainty and should only be done with trepidation.⁷⁹

Risk or *HQ* should be calculated for each concentration for each chemical for two reasons. First, to determine the relative magnitude of *risk* and/or *HQ* to identify the chemicals of most potential concern. For example, if one chemical has a risk value three orders of magnitude higher than any other chemical being considered, then this chemical should be the main focus.

Second, *risk* and *HQ* should be calculated to ensure the values used in the equation are within feasible ranges. If the *HQ* values are significantly below unity for some or all of the noncarcinogenic chemicals, it may be reasonable to exclude these chemicals from further evaluation. If intake (exposure concentration) levels, are high, then it may not be reasonable to use the EPA *SFs*, and *RfCs* or *RfDs*. The EPA publishes risk assessment information about chemicals in the Integrated Risk Information System (IRIS) and from the Health Effects Assessment Summary Tables (HEAST). If sufficient quality data is available, the EPA prepares a carcinogenicity assessment for the chemical in IRIS. This assessment summarizes the data, includes all acceptable *SFs* and *unit risks*, and includes a suggested maximum exposure concentration that can be used with the *SFs* and *unit risks*. For example, in IRIS under the Benzene Carcinogenicity Assessment for Lifetime Exposure, a unit risk of 8.3×10^{-6} per $\mu\text{g}/\text{m}^3$ is provided for inhalation exposure.⁸⁰ This unit risk is followed by the statement "the unit risk should not be used if the air concentration exceeds $100 \mu\text{g}/\text{m}^3$, since above this concentration the unit risk may not be appropriate".^{80, 86} The *SF* is developed to span the region on the dose-response curve between the data points (from animal experiments and/or epidemiological studies) and the origin. When exposure concentration levels exceed the levels stipulated in IRIS they are in the range of the dose levels found in the data points. The EPA recommends using the information from the appropriate animal experiment and/or epidemiological study to determine a reasonable *SF* or *unit risk*.

A similar situation occurs when evaluating the risk from a noncarcinogenic chemical with a high exposure concentration. The *RfD* is determined from the *NOAEL* not from the dose-response curve. At exposure concentrations significantly above the *RfD*, use of the *RfD* may not accurately estimate risks since the *RfD* is a point not an expression of the adverse response in relationship to the exposure dose.⁶⁷

The *risk* or *HQ* can be calculated for various chemical emission rates using Equation 15, 16, or 17. The equations show that *risk* and *HQ* can be calculated from simple linear equations given the scenario and assumptions used. In essence, for a given *Q* the difference in *risk* is determined from the different *SF* and the difference in *HQ* is determined from the reciprocal of the different *RfC* or *RfD*.

$$Risk_i = Q_i \times (4 \times 10^{-4}) \times SF \quad \text{Equation 15}$$

$$HQ_i = \frac{Q_i \times (4 \times 10^{-4})}{RfD} \quad \text{Equation 16}$$

$$HQ_i = \frac{Q_i}{RfC} \quad \text{Equation 17}$$

Where:

<i>Risk_i</i>	-	Risk estimate for chemical emission rate <i>Q_i</i>
<i>Q_i</i>	-	Chemical emission rate, <i>i</i> = 1,2,3,... (mg/sec). <i>Q₁</i> is the emission rate for chemical #1, <i>Q₂</i> is the emission rate for chemical #2, etc.
<i>HQ_i</i>	-	Hazard quotient estimate for chemical emission rate <i>Q_i</i>

The change in *risk* or *HQ* can be calculated using Equation 18 or 19.

$$\Delta Risk = Risk_{i+1} - Risk_i \quad \text{Equation 18}$$

$$\Delta HQ = HQ_{i+1} - HQ_i \quad \text{Equation 19}$$

Total change in *risk* or *hazard index (HI)* (sum of all hazard quotients) for numerous chemicals can be calculated using Equation 20 or 21. Only the inhalation pathway is evaluated.

$$\Delta Risk_{Total} = \sum_{i=1}^n \Delta Risk_i \quad \text{Equation 20}$$

$$\Delta Hazard Index = \sum_{i=1}^n \Delta HQ_i \quad \text{Equation 21}$$

As with any risk assessment, the values calculated from these equations must be accompanied by the assessment and presentation of assumptions, uncertainties, and scientific judgements. Site specific concerns should also be discussed.

9.4 Comparing Chemicals - Toxicity and Carcinogenic/Noncarcinogenic Issues

9.4.1 Introduction

The risk reduction model proposed in Section 9.3 evaluates the risk from exposure from chemicals solely on the *SF* or *RfC* values. There are limitations to this comparison chemicals. The *SF* or *RfC* values are determined from varying amounts and quality of data. For a few of the 189 HON chemicals, extensive research has been completed to evaluate the adverse effects of the chemical. For example, the EPA set the weight of evidence of carcinogenicity for benzene at A because of the extensive body of data available. In comparison, several chemicals have no *SF* or *RfC* values in IRIS although values are proposed in HEAST, which implies less confidence in the values. Comparing chemicals with different adverse effects, using *SFs* and *RfCs*, that have different levels of confidence because of the toxicological data available, makes direct comparison of the risk associated with exposure difficult. Attempting to compare carcinogenic risk to noncarcinogenic hazard quotient values is even more difficult because of the differences in the meaning of *SF* and *RfC*, and how they are determined.

The EPA has addressed these issues to some extent in three evaluation systems. Each system is summarized below and the chemical comparisons discussed.

9.4.2 Toxicity Comparison

9.4.2.1 Introduction The differing toxicities of the HAPs and the lack of conclusiveness of the *SF* and/or *RFC* complicates the use of risk assessments in many applications. The EPA has attempted to address this issue in three separate evaluation systems. Two are part of finalized regulations and the third part of a proposed regulation. The first evaluation system is the revised Hazard Ranking System (HRS) which is the principal mechanism for placing sites on the National Priorities List (NPL) as part of the "Superfund" program.⁸¹ The second system is a ranking of certain high-risk pollutants under the Early Reduction Provision (ER Rule) of the 1990 CAAA.⁸² The third system is the proposed Requirements for Control Technology Determinations for Major Sources in Accordance with CAAA Sections 112(g) and 112(j).⁸³

9.4.2.2 Hazard Ranking System The HRS serves as a screening device to evaluate the potential for releases of uncontrolled hazardous chemicals to cause human health or environmental damage. The HRS provides a measure of relative rather than absolute risk and is designed to be applied to a wide variety of sites. The HRS score is derived from an evaluation of potential pathways and involves estimating the likelihood of chemical release, the chemical waste characteristics, and the location and characteristics of possible population targets.

Part of the chemical waste characteristics evaluation is the selection of the chemical that has the potential to pose the greatest hazard.⁸¹ An assigned value is determined for each waste chemical at the site using one of three toxicity factor evaluation tables. The tables are listed in Appendix A. The first table, for chronic toxicity (noncarcinogens), assigns values ranging from 0 to 10,000 depending on the *RfD* value. For example, $RfD < 0.0005$ mg/kg-day is assigned a value of 10,000 and a $RfD \geq 0.5$ mg/kg-day is assigned a value of 1. The second table, for carcinogenicity, assigns the same values depending on the weight of evidence and slope factor.

For example, an assigned value of 10,000 is given to chemical with a weight of evidence of A and $SF \geq 0.5$, or a weight of evidence of B and $SF \geq 5$, or a weight of evidence of C and $SF \geq 50$. The third table, for acute toxicity, assigns values ranging from 0 to 1000 depending on the lethal concentration (defined in the Glossary) LC_{50} , or the lethal dose, LD_{50} . For example, an oral $LD_{50} < 5$ (mg/kg), or a dermal $LD_{50} < 2$ (mg/kg), or a dust or mist $LC_{50} < 0.2$ (mg/l), or a gas or vapor $LC_{50} < 20$ (ppm) are assigned values of 1000.

The EPA stresses that the use of the tables is for cursory scoring of sites using the HRS. The assigned values are determined for each chemical and used with persistence factors to evaluate final toxicity/mobility values for the various pathways. Given the limitations, the tables still provide a method for comparing the relative toxicity of carcinogenic and noncarcinogenic chemicals. This evaluation system ranks hazardous chemicals by their RfD and/or SF but also incorporates additional emphasis for chemicals with known or limited evidence of human carcinogenicity.

9.4.2.3 Early Reduction Provision The second evaluation system, the ER Rule, establishes requirements and procedures for polluting facilities (or sources) to obtain compliance extensions by significantly reducing hazardous air pollutants before the regulations requiring the pollutant reductions are promulgated. The ER Rule contains certain restrictions pertaining to emissions of high-risk or very toxic hazardous air pollutants in response to statute requirements. The regulation is designed to strongly discourage any emission of high-risk pollutants or require a significant reduction of other lower-risk pollutants as compensation if minute quantities of the high-risk pollutants will be emitted.⁸⁴

The ER Rule contains a list of 47 high-risk pollutants, a subset of the original 189 Title III HAPs. The table is in Appendix A. The high-risk pollutants are given weighting factors ranging from 10 to 100,000. The other 142 chemicals are considered lower risk and are given

a weighting factor of 1. The EPA states the table provides a measure of relative toxicity for the 189 listed chemicals although the weightings for the high risk noncarcinogens are "rough".⁸⁴

The weighting factors specify the equivalent offsets for trading among the listed chemicals. For example, a source emitting one ton of hydrazine with a weighting factor of 100, wishes to participate in the early reduction program but is unable to achieve the required 90% reduction in hydrazine emissions. The source can offset the shortfall by achieving greater than necessary reductions of another listed chemical. If the achievable hydrazine reduction was 0.8 tons (80%) and the source also emitted 40 tons of benzene, the hydrazine shortfall of 0.1 tons could be offset by reductions in benzene of $[0.1 \text{ tons hydrazine}] \times [100/10]$ (the ratio of the weighting factors for hydrazine and benzene) which is equal to 1.0 ton benzene.

The ER table was developed by evaluating the following for the 189 chemicals: known human carcinogenicity (weight of evidence), carcinogenic potency, systemic effects (other than cancer), and acute lethality.⁸⁵ Additional factors incorporated include statutory requirements, persistence in the environment and bioaccumulation.

The ER Rule evaluation system is useful for ranking the toxicity of pollutants if the chemicals of interest are on the list of high-risk pollutants. The relative ranking of the carcinogens is well justified, although the noncarcinogen ranking appears to be fairly arbitrary.

9.4.2.4 Control Technology Determinations The third evaluation system, the proposed Requirements for Control Technology Determinations for Major Sources in Accordance with CAAA Sections 112(g) and 112(j), or Section 112(g) as it is commonly called, incorporates the Title III MACT standards for HAPs within the Title V, Permit, program. The proposed rule is for new facilities or major modifications to existing facilities and outlines how MACT requirements shall be incorporated within a facility's air permit, particularly when no applicable Federal emission limitation has been promulgated. The rule includes proposed de minimis

emission rates for all of the listed HAPs and defines how an owner or operator may provide emission offsets to avoid requirements for modifications. Procedures are included for evaluating whether emission offsets meet the statutory requirement of being more hazardous than emission increases being offset. The more hazardous evaluation is based on four tables listed in Appendix A: Table XLI - Nonthreshold Pollutants (carcinogenic), Table XLII - Threshold Pollutants (noncarcinogenic), Table XLIII - High-Concern Pollutants, and Table XLIV - Unrankable.⁸³

In Table XLI, the carcinogenic pollutants are ranked by weight of evidence and an ED10 potency value which is the dose associated with a 10% increase over background in cancer incidence.⁶⁸ In Table XLII, the noncarcinogenic pollutants are ranked by a chronic toxicity scoring system developed by the EPA under the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) in establishing reportable quantities. This scoring system incorporates both the dose and severity of effect into a composite score. Table XLIII contains both carcinogenic and noncarcinogenic pollutants which are either: potent chronic toxicants, potent acute toxicants, or carcinogens with chronic toxicity outweighing that of its carcinogenicity. Only a few of the noncarcinogenic pollutants in this table are ranked. In Table XLIV, the unrankable pollutants have not yet been evaluated sufficiently to be ranked.

The Control Technology Determination evaluation system provides some ranking of chemicals. The chemicals in Table XLIII are considered higher risk than those in Tables XLI and XLII, and the chemicals within Table XLI and XLII are ranked. The rankings are subject to change since this proposed rule is expected to be finalized during the summer of 1995 and is subject to modifications.

9.4.3 Carcinogen - Noncarcinogen Comparison

Although comparing the toxicities of chemicals is difficult, attempting to compare risks between carcinogen and noncarcinogen chemicals is nearly impossible using the current *SF*, *RfC* systems. To summarize the differences, the noncarcinogen *RfC* system relies on the concept of a threshold. A chemical's *RfC* can be used to evaluate exposures for possible adverse effects. The carcinogen system assumes no threshold and instead relies on a *SF*. The *SF* is the slope of the dose-response curve between the origin and the experimental data points. Because of the differences and methods of calculation, *risk* and *HI* can not be directly compared.

In certain circumstances, for example the proposed risk reduction model, it would be helpful to have an approximate, order of magnitude, method of comparing risk and hazard quotient values. The EPA has attempted to address this issue in the three rules introduced in Section 9.4.2.

In the HRS evaluation system, carcinogen and noncarcinogen chemicals can be compared by determining the assigned value from the tables and comparing the values. But, the tables were not developed with a consistent ratio of *risk* to *HQ* equivalency. The range of ratios varies with an equivalency ratio of risk of 1×10^{-6} approximately equal to *HQ* of 1 for the most toxic noncarcinogenic chemicals (*RfD* < 0.0005 (mg/kg-day)) and the most toxic, well understood carcinogenic chemicals (weight of evidence A and *SF* < 0.5 (mg/kg-day)⁻¹). For chemicals with much lower toxicities and when less information is known about the carcinogenic chemical (the weight of evidence moves to B or C), the ratio moves closer to a *risk* of 1 being equivalent to a *HQ* of 1.

In the ER Rule, carcinogens and noncarcinogens were directly compared to develop the list of high-risk pollutants. In the preamble to the ER Rule a risk of 1×10^{-3} is defined as being equivalent to a *HQ* of 1.⁸² But, EPA contradicted this definition by setting the weighting factors

for noncarcinogenic chemicals at 10 for the 15 high-risk noncarcinogens because "comparable measures of relative toxicity do not currently exist for noncarcinogens".⁸⁵ The weighting factors were increased to 100 for seven chemicals because of adverse health effects, persistence in the environment, and bioaccumulation.

The 112(g) rule avoided the carcinogen, noncarcinogen question because the statute decreed that increases in emissions of carcinogen pollutants could not be offset by decreases in noncarcinogen pollutants.⁶⁸ The only exception is noncarcinogen chemicals not on the high-concern pollutant list are considered less toxic than all the carcinogen chemicals.

9.4.4 Conclusions

The three evaluation systems, HRS, ER Rule, and Section 112(g), discussed in this chapter are significantly different in their approach for evaluating pollutant toxicities. Using any one of the systems gives a different ranking than the other two systems. For example, the assigned values from the HRS show no relationship to the weighting factors in the ER List of High-Risk Pollutants and in general, the pollutants on the ER List are not the pollutants in Table III, High-Concern Pollutants of the 112g proposed rule. Given the inconsistencies of the EPA evaluation systems, the risk reduction measurement model in this research will rely on the *SF* and *RfC* values from IRIS and HEAST due to their availability and acceptance in the risk assessment community. Weight of evidence and other relevant information about the chemicals evaluated will be included in the narrative included with each evaluation.

Although, carcinogenic risk and noncarcinogenic hazard quotients can not be directly compared, the three evaluation systems address the issue. For the proposed risk reduction model the definition in the ER Rule of a *risk* of 1×10^{-3} being roughly equivalent to a *HQ* of 1 is used.

This equivalency ratio will only be used to evaluate the magnitude difference between the $\Delta Risk_{Total}$ and the $\Delta Hazard Index$. Example 3 below provides an example.

9.5 Applying the Risk Reduction Measurement Model

The use of the Risk Reduction Measurement Model is demonstrated in three examples. The first example explains the use of the model to calculate the change in risk from a facility when RCT is applied to an emission point. The second example illustrates the use of the model in comparing change in risk from different pollution control options. The change in risk values from example 1 are compared with the change in risk after pollution prevention projects are used to control the emissions instead of RCT. Example 3 is similar to example 2 except the carcinogen - noncarcinogen comparison issue is addressed.

9.5.1 Example 1 - Evaluating Change in Risk from Applying Reference Control Technology

The following scenario demonstrates the use of the risk reduction measurement model. In this example, HAPs are being emitted from several process vents or stacks at a HON regulated facility. Table X lists the HAPs used in the example and a total emission rate for each chemical. The weight of evidence, SF and RfC values are included for each chemical. The risk assessment data was found in EPA Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (HEAST).^{86,78} For the carcinogenic chemicals, only a SF is included in the table. There are also RfC values available for some carcinogenic chemicals, but they are not included in this example for simplicity. The carcinogen - noncarcinogen comparison issue is addressed in Example 3. An appropriate value for Q_i , the initial emission rate, was determined from the Title III definition of major source that requires compliance for any facility

emitting 10 tons/year of one HAP or 25 tons/year of two or more HAPs. Ten tons/year converts to approximately 300 mg/sec.

Table X. HAPs Emitted from Example Facility

HAP	Q_1^1 mg/sec	WoE ²	SF ³ kg-day/mg	RfC ⁴ $\mu\text{g}/\text{m}^3$
Acrylamide	300	B2	4.6	
Benzene	300	A	2.9×10^{-2}	
Ethylene oxide	300	B1	0.35	
Acrolein	300			0.02
Hexachlorocyclopentadiene	300			0.07

Where: ¹ Q1 - Original concentration being emitted
² WoE - Weight of evidence
³ SF - Slope factor
⁴ RfC - Inhalation reference concentration

In this example the original emissions from the facility, Q_1 , are compared with the emissions after RCT is installed, Q_2 . RCT for process vents is a flare rated at 98% emissions reduction. Table XI shows concentration levels, reduction percent, *risk* or *HQ* for each concentration level, change in risk, and change in hazard quotient. Total change in risk, $\Delta Risk_{Total}$, and the change in hazard index, ΔHI , from Equations 20 and 21, is also shown.

The negative signs on $\Delta Risk$ and ΔHQ numbers indicate a decrease in risk. Only one significant figure is used for all values. The $Risk_i$ and HQ_i values are very high; a risk of 0.5 means half the exposed people may develop cancer and a HQ of 2×10^4 is four orders of magnitude greater than the "safe level" of 1. These values are extreme due to the many conservative assumptions made in the risk reduction model and because of the high concentration

Table XI. Estimating Change in Risk, Example 1

HAP	Q_1^1 (mg/sec)	$Risk_1^2$	Reduc ³	Q_2^4 (mg/sec)	$Risk_2^5$	$\Delta Risk^6$
Acrylamide	300	0.6	98	6	0.01	-0.6
Benzene	300	3×10^{-3}	98	6	7×10^{-5}	-3×10^{-3}
Ethylene oxide	300	0.04	98	6	8×10^{-4}	-0.04
$\Delta Risk_{Total}$						-0.6
		HQ_1^7			HQ_2^8	ΔHQ^9
Acrolein	300	2×10^4	98	6	300	-2×10^4
Hexachlorocyclopentadiene	300	4×10^3	98	6	90	-4×10^3
ΔHI						-2×10^4

- Where:
- ¹ Q_1 - Original concentration being emitted
 - ² $Risk_1$ - Estimated risk associated with Q_1 , Equ. 15
 - ³ Reduc - Reduction of Q_1 emissions, (%)
 - ⁴ Q_2 - Concentration being emitted, example 1
 - ⁵ $Risk_2$ - Estimated risk associated with Q_2 , Equ. 15
 - ⁶ $\Delta Risk$ - Change in risk, Equ. 18
 - ⁷ HQ_1 - Estimated hazard quotient associated with Q_1 , Equ. 17
 - ⁸ HQ_2 - Estimated hazard quotient associated with Q_2 , Equ. 17
 - ⁹ ΔHQ - Change in hazard quotient, Equ. 19

level, Q_1 . The 98% reduction in emissions to Q_2 cause expected significant reductions in both risk and HI.

The $\Delta Risk$ and ΔHQ values are the most usable values in the table because they represent the reduction in risk caused by the emissions reduction. Unlike the $Risk_i$ and HQ_i values, they are reasonably accurate for the given scenario because all other variables are held constant except Q . The $\Delta Risk$ and ΔHQ values allow comparison between the various chemicals to determine the most toxic to the local community and therefore the most important to reduce. For example, because only one significant figure is used, all the $\Delta Risk_{Total}$ is from one chemical, acrylamide, and all the ΔHI is from one chemical, acrolein.

The $\Delta Risk_{Total}$ and ΔHI values indicate all risk has been elevated because only one significant figure can be justified in the calculations. The values in the $Risk_2$ and HQ_2 columns indicate that all risk has not been prevented. If the true *risk* and *HQ* values are required after implementation of a pollution control option, then a facility specific, thorough risk assessment must be conducted.

Since the Q_1 values are so high, the *risk* and *HQ* calculations are outside the reasonable range of using the *SF* and *RfC* values. The Q_2 values are low enough that using the *SF* and *RfC* values is within the recommend range. The only alternative to using the *SF* and *RfC* values with the high concentration levels is to research the toxicology data for a more appropriate value of *SF* or *RfC*. This risk reduction model will rely on the EPA *SF* and *RfC* values and document where their use is outside the recommended range. The justification stems from the availability of the *SF* and *RfC* values and purpose of the model; to evaluate the magnitude of change in risk, not to estimate actual *risk* or *HQ*.

The toxicity comparison issues discussed in Section 9.4.2 are evident in this example. All the $\Delta Risk_{Total}$ is from acrylamide which has a weight of evidence of B2 (probable human carcinogen - sufficient evidence in animals, insufficient evidence in humans). Whereas benzene, with a weight of evidence of A (human carcinogen), does not influence the $\Delta Risk_{Total}$. Limited toxicological information is available on acrylamide, yet the analysis of example 1 relies on the $\Delta Risk$ value for this chemical. The *SF* for acrylamide is subject to change as more toxicological data becomes available. The risk reduction model will rely on the available *SF* and *RfC* values, because they are the best information available. The uncertainties should be documented with the risk assessment. The noncarcinogenic chemicals are subject to the same variability of toxicological data. IRIS includes a confidence level of low, medium, and high for all *RfD*, *RfC* values.

9.5.2 Example 2 - Comparing Change in Risk from RCT and Pollution Prevention Control Options

The second example compares the original emissions from the facility, Q_1 , with the emissions, Q_3 , assuming two pollution prevention projects were implemented. Because of the toxicity of acrylamide, a non-toxic chemical was substituted for acrylamide in the process, thereby reducing the emissions to zero. The other HAPs were reduced 80% using an in-line recycling system. Table XII shows concentration levels, reduction percent, risk or hazard quotient for each concentration level, change in risk, and change in hazard quotient. Total change in risk ($\Delta Risk_{Total}$) and the change in hazard index (ΔHI) is also shown.

Table XII. Estimating Change in Risk, Example 2

HAP	Q ₁ (mg/sec)	Risk ₁	Reduc	Q ₃ (mg/sec)	Risk ₃	ΔRisk
Acrylamide	300	0.6	100	0	0	-0.6
Benzene	300	3 × 10 ⁻³	80	60	7 × 10 ⁻⁴	-2 × 10 ⁻³
Ethylene oxide	300	0.04	80	60	8 × 10 ⁻³	-0.03
ΔRisk _{Total}						-0.6
		HQ ₁			HQ ₃	ΔHQ
Acrolein	300	2 × 10 ⁴	80	60	3 × 10 ³	-2 × 10 ⁴
Hexachlorocyclopentadiene	300	4 × 10 ³	80	60	900	-3 × 10 ³
ΔHI						-2 × 10 ⁴

Where: Q_3 - Concentration being emitted, example 2

Table XII illustrates some interesting concepts. Changing the reduction percent, for all HAPs other than acrylamide, from 98 to 80 had effectively no impact on the change in risk or hazard index. This raises questions about why the percent reduction of emissions requirements

in the HON standards are so rigid. Small differences in percent reduction are insignificant to changes in risk. One of the advantages of the risk reduction model is its usefulness in designing a pollution prevention program to reduce risk to the greatest extent. In example 2, the most toxic carcinogenic chemical (acrylamide) was eliminated which significantly reduced the risk to the local community.

Comparing Table XI, example 1, and Table XII, example 2, demonstrates the value of this risk reduction measurement model in evaluating alternative methods of compliance. In example 2, the HAP emissions are higher than example 1, but the total change (reduction) in risk is the same for both examples. The example 2 compliance program was designed to reduce the most toxic pollutant to reduce the greatest risk. Because of the limited sensitivity of the equations used to calculate the change in *HI*, no change was noted between example 1 and 2. The values indicate that from a risk perspective, implementation of the pollution prevention projects is at least as beneficial as installing the RCT. A thorough comparison of example 1 and 2 would require consideration of many other factors, such as cost, energy use, and environmental factors (waste products). These are discussed in Chapter 8, Total Cost Assessment.

Although the $\Delta Risk$ and ΔHI values are the same in Tables XI and XII, the $Risk_2$, $Risk_3$, and the HQ_2 , HQ_3 values differ by an order of magnitude. The value of the risk reduction measurement model is in evaluating change in risk, not the individual risk of the pollution control options.

9.5.3 Example 3 - Comparing $\Delta Risk$ and ΔHQ

Example 3 demonstrates the carcinogen versus noncarcinogen issue discussed in Section 9.4.3. For this example, the facility has a process line that has one Group 2 process vent. The owners of the facility are considering incorporating one of two pollution prevention projects on

the process line to reduce wasted resources and to use the emissions reduction as part of their Alternate Compliance Strategy program. Table XIII summarizes the risk data for the two pollution prevention projects. Scenario 1, the first pollution project, reduces acrylamide by 100% but acrolein by only 50%. $\Delta Risk$ is -0.6 and ΔHQ is -1×10^4 . Scenario 2, the second pollution project, reduces acrylamide by only 50% but acrolein by 100%. This gives a $\Delta Risk$ of -0.3 and a ΔHQ of -2×10^4 . The question is, Which scenario reduces the risk to the local community more? Scenario 1 reduces *risk* more, but scenario 2 reduces the *HQ* more.

Table XIII. Estimating Change in Risk, Example 3

Scenario 1	Q_1 (mg/sec)	Risk ¹	Reduce	Q_4 (mg/sec)	Risk ₄	$\Delta Risk$
Acrylamide	300	0.6	100	0	0	-0.6
		HQ ₁			HQ ₄	ΔHQ
Acrolein	300	2×10^4	50	150	8×10^3	-1×10^4
Scenario 2	Q_1	Risk ₁	Reduce	Q_4	Risk ₄	$\Delta Risk$
Acrylamide	300	0.6	50	150	0.3	-0.3
		HQ ₁			HQ ₄	ΔHQ
Acrolein	300	2×10^4	100	0	0	-2×10^4

Where: Q_4 - Concentration being emitted, example 3

If the $\Delta Risk$ and ΔHQ numbers could be directly compared, scenario 2 would be more beneficial because of the orders of magnitude difference in the *risk* and *HQ* numbers. But as discussed in Section 9.4.3, *risk* and *HQ* can not be directly compared. In order to evaluate which pollution prevention project to implement or many other similar issues an equivalency ratio is necessary. No equivalency ratio can be entirely justified from a scientific standpoint, but its

usefulness is significant. The ER Rule included such an equivalency ratio defining a *risk* of 1×10^{-3} being roughly equivalent to a *HQ* of 1. This equivalency ratio will be incorporated with in the risk reduction measurement model but only to evaluate the magnitude difference between the $\Delta Risk$ and ΔHQ , or $\Delta Risk_{Total}$ and ΔHI .

For example, comparing Scenario 1 and 2, $\Delta Risk$ was -0.6 for Scenario 1 and -0.3 for Scenario 2 with a difference of 0.3. ΔHQ was -1×10^4 for Scenario 1 and -2×10^4 for Scenario 2 with a difference of 1×10^4 . Using the ER Rule a risk of 0.3 is roughly equivalent to 3×10^2 HQ. Therefore, Scenario 2 is possibly lower risk to the local community than Scenario 1 and should be considered for implementation.

9.6 Additional Considerations and Summary

The emission source for this model was assumed to be a process vent or stack. There are other types of emission sources; tanks, wastewater systems, and fugitive emissions (leaking pipes and valves). The equations and model presented here can be used for the other emission sources if the chemical concentrations are known. The main difference between the emission sources, in risk assessment, is in dispersion modeling. This risk reduction measurement model assumes a very short distance downwind and no loss of pollutant. True risk assessments would possibly show different levels of risk for the different types of emission sources, but because the risk reduction measurement model estimates the magnitude of change in risk, the errors incurred are minimal.

Air emissions from organic chemical manufactures and most other industry are mixtures of many chemicals, often at high temperatures, and there is concern that the pollutants are not stable. Instability can affect the fate of the individual chemicals and the compounds people are ultimately exposed to. Instability is a function of the specific chemicals, concentrations, and the

conditions. Research is being conducted on certain mixtures. For any evaluation, if information is available on the dynamics of the chemicals in the emissions, it should be incorporated in the narrative.

This chapter developed a risk reduction measurement model to evaluate the magnitude change in risk to communities near a facility releasing air pollutants. Three HAP comparison systems developed by the EPA were summarized and discussed. Each of the EPA systems, which bear little resemblance to each other, were developed for different, specific purposes. The risk reduction measurement model is useful in evaluating alternate compliance options and estimating the magnitude change in risk and hazard index from changes in the quantity and type of pollutants released. The model is used in Chapter 12 to evaluate the change in risk for compliance options at the baseline facility discussed in Chapter 11.

The use of the risk reduction measurement model is not limited to HON rule applications. It is relevant for other Title III applications and will facilitate addressing the risk questions about pollution prevention and other innovative compliance options so that the basic intent of the statute can be met - maximum achievable control of HAPs. The model is also useful in encouraging the acceptance of pollution prevention compliance options in other air pollution applications. Further research is needed in addressing the toxicity comparison and carcinogen, noncarcinogen issues, and to adapt the risk reduction measurement model to other media.

X. Selecting an Example Facility

10.1 Introduction

In order to compare the Alternate Compliance Strategy (ACS) with the compliance methods in the HON rule, the evaluation methods discussed in Chapters 8 and 9 needed to be applied to an example facility. Selecting the example facility required establishing the criteria for selecting the facility and comparing the criteria to available facilities.

This chapter contains three sections. Section 10.2 defines and discusses the two classes of criteria used for selection of the example facility. Section 10.3 explains the procedure used in identifying and contacting potential facilities, and then gathering data from those that showed interest. Section 10.4 describes how the example facility was selected.

10.2 Criteria for Selection

Two classes of criteria, general and specific data, were used to evaluate facilities for possible use in this research. General criteria include characteristics and information necessary for a facility to be considered as an appropriate example. Specific data criteria for a facility include four types of data (process definition, background, compliance, and pollution prevention) for use in the compliance method comparison.

The four general criteria include:

1. The company or facility must be regulated by the HON rule.
2. The company must have a documented current and proposed pollution prevention program.
3. The company must have documentation and data of emissions sources and applicable processes regulated by the HON rule.

4. The company must be receptive to participating in this research.

Meeting these four criteria were essential for any facility to be used for an example. The necessity of being regulated under the HON relates back to the focus of the ACS. The emissions data and pollution prevention information are necessary to prepare compliance programs. The fourth criteria is needed because the depth of the data necessary to complete this research is not available in the public domain. Size of the company or individual facilities was not considered significant.

Specific data criteria includes the four types of data needed to complete the implementation plans in Chapter XI. It was realized all the requested data would not be available and some would have to be estimated. The first type of information was the assistance in defining and selecting a production process or group of process lines or facility regulated under the HON rule. Most synthetic organic manufacturing companies have facilities with tens or even hundreds of processing lines at each facility. Only some of the processing lines are regulated under the HON rule. In order to complete the research, one process line or a small group of process lines was needed that met all the general criteria, and had available most of the information discussed below.

The second type of data needed about the selected process was background information. Information was needed about the facility and process in general and specifics about the defined process line or project area. Specific background information included information on operations, processes, recent and planned modifications, and completed and planned pollution prevention programs.

The third type of data needed, was specific compliance data on the selected project area or process. All data and information that the environmental management personnel had compiled and prepared in preparation for compliance with subparts F & G of the HON rule was needed.

This included a copy of the initial notification which was due August 1994 and any available information on Group 1 and 2 emission sources. Also needed was any information available for calculating the allowed emission rate, E_A , Equation 1, Chapter 7, and any emissions averaging data if being used for part of the compliance program. All available information on the compliance requirements on the selected process unit was needed. For example, which reference control technology was being used for each Group 1 source, cost of reference control technologies being installed, cost of monitoring equipment, projected energy requirements, etc.

The fourth type of data was specific information on the pollution prevention program at the selected process or project area. Data and information were needed on pollution prevention projects that were being or could be implemented in place of the reference control technology. Cost to implement, emissions reduced, energy usage, and engineering specifics were needed for all pollution prevention projects.

10.3 Procedure Followed in Selection

The procedure used to find appropriate facilities for use as an example that met the criteria included contacting potential facilities and gathering data from those facilities that looked most promising.

10.3.1 Identifying and Contacting Potential Facilities

Environmental managers, preferably the air issue manager, in potential companies were identified and contacted. A list of facilities possibly regulated by the HON rule was obtained from the EPA Technology Transfer Network.⁸⁷ The list included approximately 700 production processes, with company name and location, that in 1990 the EPA concluded might be regulated by the then future HON regulation. Using a professional network which included the American

Institute of Pollution Prevention, the Association of Air & Waste Management, and professors, environmental managers from some of the companies on the EPA list were contacted. A few other companies, not on the HON list were also contacted because of their potential value in the research. The identified environmental managers were called, received an explanation of the research and were sent a copy of the research proposal with a list of requested data and information. Follow up calls usually yielded a suggestion to contact someone else, like the company's main air issue manager or the environmental managers at some potential facilities. The process continued until either a definitive yes or no answer was received or it was determined that no future progress could be made. Table XIV lists the companies contacted and summarizes the responses.

3M Corp., Dixie Chemical, Intel Corp., Mead Corp., Proctor & Gamble, and TRW Inc. stated they were not regulated under the HON rule. This statement was not expected, particularly for Dixie Chemical and Proctor & Gamble. Proctor & Gamble explained that they had changed processes enough to not be regulated by the HON rule but would be regulated by future Title III regulations. Intel provided information on a Title V permit that is being finalized in Oregon with the state and federal EPA. This draft permit is significant because it includes provisions that encourage pollution prevention and permit the necessary flexibility the semi-conductor facility requires.

When contacted, an environmental manager from AMOCO Corp. stated that the company had spent millions of dollars on the Yorktown project (Section 4.2) with very little benefit to the company; therefore, they were not interested in any other pollution prevention research projects. An environmental manager from Georgia Pacific Corp. explained that their environmental managers and engineers were too inundated with work trying to meet the many compliance requirements at their facilities to attempt to participate in the research. After

Table XIV. Contacted Companies

<u>CONTACTED COMPANIES</u>	
<u>Company</u>	<u>Response</u>
3M	Not regulated under HON
Albemarle	No response
AMOCO	Not interested
ARCO	No response
Dixie Chemical	Not regulated under HON
Dow Chemical	Interested
DuPont	Interested
Georgia Pacific	Not interested
Intel	Not regulated under HON
Mead	Not regulated under HON
Monsanto	Interested
Proctor & Gamble	Not regulated under HON
TRW	Not regulated under HON
Union Camp	Not interested

numerous attempts were made to contact environmental managers at Albemarle Corp., ARCO Corp., and Union Camp Corp., the decision was made to pursue the companies that showed interest.

The only companies that were interested in participating in the research were the major companies in the chemical industry, Dow Chemical, DuPont and Monsanto. After talking to environmental managers, it was concluded that this occurred for three reasons. First, only the large companies had sufficient environmental staffs to consider dedicating time to a graduate research project. Second, these same companies in the chemical industry had substantial pollution prevention projects whereas the smaller chemical companies had little or no pollution prevention programs due primarily to the large resource investment required. Third, because the large chemical companies were involved in the regulatory writing process, the environmental managers realized the need to change regulations and attached a higher value to the research.

The headquarters air issue manager at Dow was recommended through the Chemical Manufacturers Association (CMA) because of his proactive approach and his involvement with the EPA in writing the HON rule. The contact at Monsanto Corp. was found through a recommendation from a representative from the Synthetic Organic Chemical Manufacturers Association (SOCMA) who is also a member of AIPP. The headquarters air environmental manager was recommended because of his involvement with the HON rule and his support of pollution prevention. The headquarters air environmental manager at DuPont was found through a professor who had worked for DuPont.

After each of these three headquarter air environmental managers had reviewed the research proposal, they expressed the same concerns. They were concerned about any funds requirements, time commitment to participate, and confidentiality issues. They were appeased by explaining no funds were required and time commitments would be kept to a minimum by using existing data and documents. The confidentiality issue was partially overcome by agreeing to modify names and data as necessary, and permitting the company to review any documents before being released or published.

Eventually, each headquarters environmental manager directed the research effort towards one or two facilities that might be interested in participating. Dow recommended the Plaquemine Plant in Louisiana because of its proactive pollution prevention attitude and the Freeport Texas facilities because the environmental manager responsible for HON rule compliance implementation was interested in the research. DuPont recommended the Subine Plant in Texas because of its proactive approach. Monsanto took a different approach and recommended an acrylonitrile-butadiene-styrene (ABS) Plastics Plant in Cincinnati, Ohio. The Monsanto headquarters environmental manager stated that no HON regulated facility was interested in participating because of the current workload to get the facility in compliance, but the Cincinnati

facility was interested for two reasons. First, the ABS Plastics Plant will be regulated under one of the Title III regulations expected out in 1995 or 1996 and hoped that participating in the research would have a positive impact on the compliance options in their final rule. Second, they had participated in research efforts with the University of Cincinnati and were willing to do so again.

10.3.2 Gathering Data from Interested Facilities

After companies and processes were selected, the interested facilities were queried for additional information to determine which fulfilled the majority of the criteria. The point of contact (environmental manager) at each facility was asked for the specific data, detailed in Section 10.2. The environmental manager at the Dow Plaquemine Plant responded with a copy of the most recent Louisiana air permit application for the Glycol II plant. The Glycol II plant is one of the process lines, regulated under the HON rule, at the Plaquemine Plant. The air permit application contained considerable compliance information about the facility. The environmental manager at the Monsanto ABS Plastics Plant sent some general information on the facility, a 1993 air emissions summary, and information on the plastic manufacturing process. The environmental management personnel at DuPont Subine Plant in Texas could not come to a decision on which of the information they could release or how to handle the confidentiality issue.

The Monsanto plastic plant in Cincinnati, Ohio was visited to gather more information and evaluate the advantages of using the facility for the research example. The environmental management personnel provided limited information on the general operation of one of the plastic processing lines. Requested information, for example air permit applications, production numbers, and process specifics, was not available because of confidentiality issues. A request

for a confidentiality agreement that would allow access to the needed information was made but not granted.

Both the Dow Freeport, Texas and the Plaquemine Plant, Louisiana were visited. The environmental management personnel at the Freeport facility provided some information on a Propylene Oxide/Glycol process line that is only partially regulated under the HON rule. Copies of the non-confidential state air permits applications were made available, but they contained limited specific information. A wastewater treatment facility was also visited that may be impacted by the HON rule but no specific information was released.

At the Plaquemine Plant a confidentiality agreement was signed, and the Plaquemine environmental manager allowed release of all information in regulatory permits and applications, and most of the information in applicable engineering documents like process line upgrades and modifications. Access was also permitted to most of the information in the applicable Waste Reduction Always Pays (WRAP) projects. The WRAP program is a Dow pollution prevention program that rewards employees that submit useful waste reduction, pollution prevention, and energy reduction projects.

One additional option, an EPA database model, was considered for use as an example for demonstrating the ACS. As the EPA developed the HON rule, a baseline of emissions from the source category and the impacts of various control technologies on the source was needed. The EPA concluded that there was not enough time to survey every potentially regulated facility to gather data; instead, model emission sources were developed to represent actual emission sources. For each of the five types of emissions points, various model emission sources were developed for existing data from new sources performance standards (NSPS) for the SO₂ and other related data. The EPA then used these model emission sources to evaluate the various impacts of the alternative control technologies which included reduction in emissions of the regulated

HAPs, cost of implementing, changes in energy consumption, and changes in emissions of other pollutants indirectly affected by the new control technologies.⁸⁸ This EPA database model was used in Chapter XI in developing the estimated HAP emissions from the baseline facility. The referenced pamphlet contains an explanation of the model development and summary information, but the actual computer software program has been disabled. The validity of some of the model emission sources is suspect because they were developed with insufficient data to be truly representative.

10.4 *Selecting the Optimum Example Facility*

The facilities available as options were ranked by the extent the criteria of Section 10.2 were met. The options and ranking are shown in Table XV.

The first choice was the Dow Plaquemine Plant because it met all the general criteria and some of the specific data

Table XV. Ranked Options for the Example Facility

- | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Dow - Plaquemine Plant, LA 2. Dow - Freeport Facility, TX 3. Monsanto - Plastics Plant, OH 4. DuPont - Subine Plant, TX 5. EPA's Database Model |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

criteria. The Dow Freeport facility was ranked second because it also met the general criteria, but another trip to the facility would be required to gather the specific data. There was also the question of whether the Propylene Oxide process line, previously visited, was an appropriate example because it was only partially regulated by the HON rule.

The Monsanto Plastics Plant was ranked third because it did not meet the general criteria of being regulated by the HON rule. The facility could be an excellent example to apply the ACS to after demonstrating its use on HON facilities. In this way, possibly the ACS could be

incorporated in regulations that are not yet finalized. Before attempting to gather more information and data from the Plastics Plant, the confidentiality issue would have to be resolved.

The DuPont Subine Plant was ranked fourth because the data and information gathering stage of the process was not as advanced. The EPA's database model was listed last since it was used for determining generic values for HON regulated facilities when actual figures were not available.

XI. Applying the Alternative Compliance Strategy

11.1 Introduction

In Chapter VII, an alternative compliance strategy (ACS) was developed that incorporated pollution prevention and flexibility as an equal alternative to end-of-pipe treatment for meeting environmental compliance requirements. Chapters VIII, and IX contain the methods developed for evaluating the ACS: the criteria of interested parties, total cost assessment, and the risk reduction measurement model. This chapter applies the ACS to an example facility in order to demonstrate the use of Equation 1, and to evaluate limitations, implications and other opportunities of using the ACS. The methods used for evaluating the ACS will be applied to this example facility in Chapter XII.

Using an example facility approach to demonstrate the ACS has its limitations. The HON rule regulates facilities that manufacture as a primary product one or more of almost 500 listed chemicals.²⁹ In 1990, the EPA estimated approximately 700 individual production processes would be regulated. This example can not demonstrate how the ACS could be used at all facilities. Because of the variability of different facilities and pollution prevention programs, the ACS would have to be applied to each facility in order to demonstrate the extent of its usefulness. The value of this example is to evaluate the use of the ACS at one facility in order to gain insight into its application.

Chapter X describes how the Dow Plaquemine Plant was selected as the optimum available facility. It is believed Dow offered the Glycol II plant over the other applicable processing lines at Plaquemine because: (1) a recent air permit application was available (1993), (2) the process was relatively simple and of a standard industry-wide design, and (3) the plant was one of their marque (from a emission reduction, compliance perspective) processing lines.

The proposed method of utilizing the example facility was to gather sufficient data at the facility to calculate the required emission reductions from Equation 1 and then to develop an ACS for the facility. An abbreviated implementation plan (discussed in Section 7.3.8) was to be developed for the facility using the ACS and compared to the implementation plan the environmental personnel at the facility would be preparing using the RCT. Then the evaluation methods would be applied to both the RCT and ACS for comparison.

During contacts with environmental managers at "interested" facilities, it was realized, all the offered processing lines were almost entirely in compliance with the HON requirements. The noted exceptions were the wastewater source requirements and the paperwork requirements. The processing lines offered were in compliance because of four reasons. One, existing federal, state, and local regulations have required significant HAP emissions reductions. For example, the federal benzene standard and new source performance standards (NSPS) have levied stringent requirements on many facilities, and the majority of states with significant chemical manufacturing have rigid HAP emissions limitations. Two, all the companies that were interested in participating in the research were the major chemical manufacturing giants that have made significant strides in the past decade to improve their public image through researching and implementing emission reduction and pollution prevention programs.⁸⁹ Three, these companies have researched and implemented ways to reduce emissions in order to conserve resources, save money, and increase their competitive edge. Four, all the process lines offered were probably the best, in emission reduction and pollution prevention programs, the company had to offer. It is presumed, no company wanted an outsider evaluating, documenting, and publishing information on a marginal facility.

After reviewing the 1993 Louisiana Air Toxics Permit Application for the Plaquemine Glycol II plant and realizing that essentially all HON compliance requirements were met, a new

approach to demonstrating the use of the ACS was needed.⁹⁰ It was decided to develop an example baseline facility resembling the Glycol II configuration plant as it was in January 1987. This date was used to allow full credit for pollution prevention efforts in the ACS implementation plan. The ACS implementation plan was developed incorporating the measures the facility had taken to reduce emissions. A RCT implementation plan was also developed for the baseline facility for comparison.

The rest of this chapter is used to develop the baseline facility and two implementation plans. Section 11.2 provides background information on the processes and products in the Glycol II plant (which makes ethylene oxide and ethylene glycol). The baseline facility is developed using a variety of information sources to characterize the emissions from the facility. The information from the references was in a variety of units. The summarized information is documented in its original units to facilitate comparison to the references. The information and data are converted in the analysis to the metric system units to correspond to the HON rule requirements. Conversion factors are provided in Appendix B.

Sections 11.3 and 11.4 contain the abbreviated implementation plan for using RCT and the ACS at the baseline facility, respectively. Section 11.5 compares the baseline facility compliance programs to the Plaquemine Glycol II plant. Section 11.6 includes a summary and discussion.

11.2 Baseline Facility

11.2.1 Introduction

The Glycol II Plant at Plaquemine is one of twelve facilities in the USA that produce ethylene oxide (EO) and ethylene glycol (EG).⁹¹ EO is a very reactive, colorless gas at ambient

conditions and is a very versatile chemical intermediate. It is an excellent disinfectant, although the majority is converted into products, like solvents, plasticizers, cosmetics, pharmaceutical preparations, brake fluids, and soaps.⁹²

Ethylene glycol, a colorless, odorless liquid under ambient conditions, is made by hydrating ethylene oxide. EG is mainly used as antifreeze, although some is used as raw material for the manufacture of polyester fibers, plastic containers, hydraulic fluid and other substances. The chemical configuration of EO, EG, and EG homologues are shown in Figure 1.

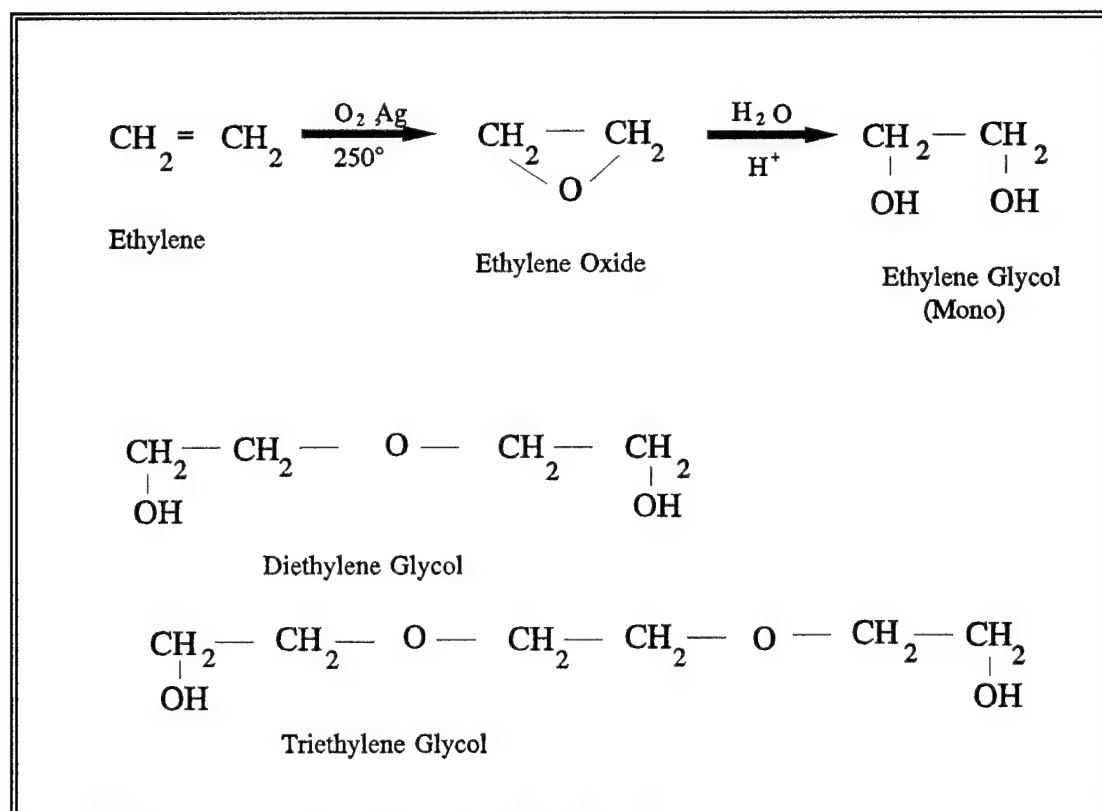


Figure 1. Chemical Configurations of EO, EG

The remainder of this section is in two parts. First, a facility description is provided which summarizes the EO and EG processes. Second, the baseline facility emissions and other process data are determined from various references.

11.2.2 Facility Description for EO and EG Processes

Ethylene oxide is produced using either an air-based or oxygen-based process. Newer facilities are typically oxygen-based.⁹¹ The baseline facility is assumed to be an air-based facility since the Plaquemine Glycol II Plant was air-based until 1990. The change to oxygen-based will be incorporated in the ACS implementation plan. A simplified schematic of an air-based ethylene oxide plant is shown in Figure 2.

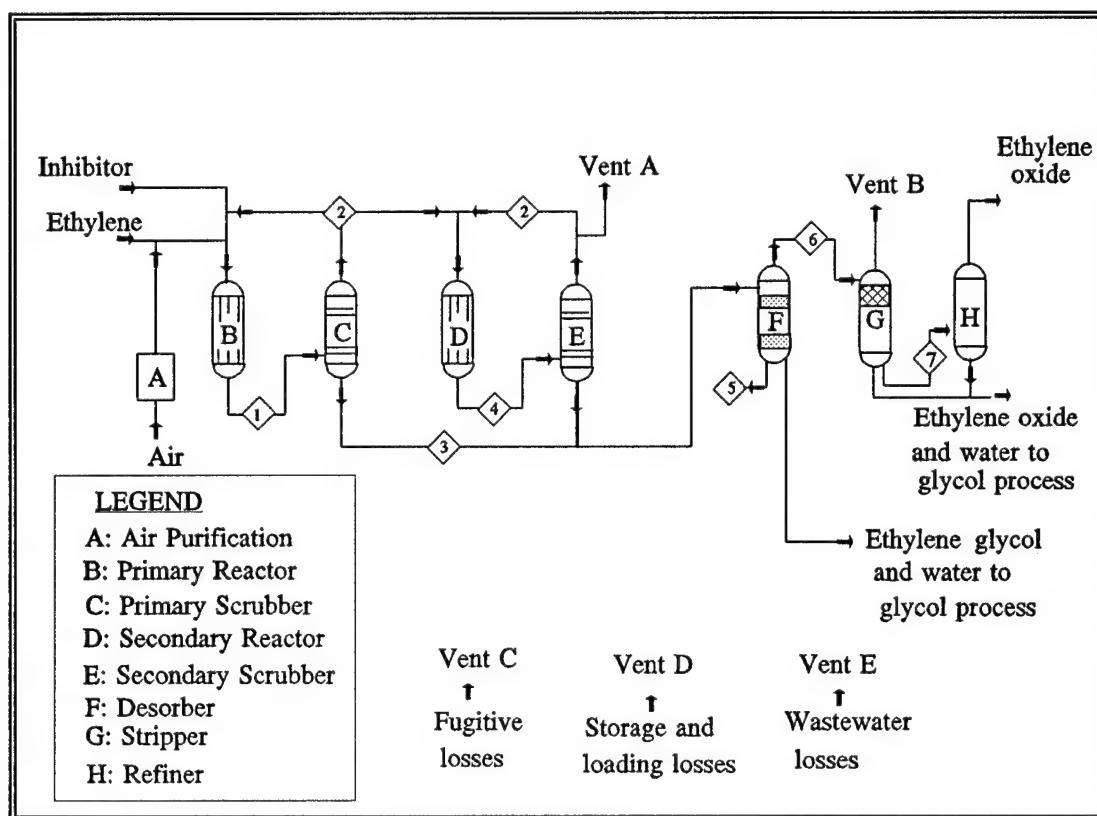


Figure 2. Air-based Ethylene Oxide Process

Table XVI. Description of Equipment and Streams for the Air-based Ethylene Process

<u>Equipment</u>	<u>Description</u>
A	Air Purification. Cleans the air before introduction into the reactor.
B	Primary Reactor. Ethylene, compressed air, and a recycle ethylene gas stream are combined and reacted over a silver catalyst packed in tubes. Air to ethylene feed ratio is approximately 10:1 by weight. Conversion of ethylene to ethylene oxide (EO) is approximately 70%. Reaction temperature and pressure are maintained at 220°C to 280°C and 1 to 3 MPa. Reaction heat is dissipated by a jacket of heat transfer fluid. Inhibitors such as halides are added to suppress conversion of ethylene to CO ₂ . Small amounts of formaldehyde and acetaldehyde are formed as by-products.
C	Primary Scrubber. Hot gas from the reactor is washed with cold water which dissolves the EO, some of the CO ₂ , hydrocarbons, and aldehydes.
D	Secondary Reactor. Some of the gas exiting the primary scrubber (C), is further reacted to achieve an overall ethylene conversion exceeding 95%.
E	Secondary Scrubber. Operates like primary scrubber. Some of exiting gas is purged in Vent A to prevent buildup of CO ₂ , nitrogen, and other inert gases.
F	Desorber. The dilute aqueous solutions from the scrubbers are distilled under reduced pressure to remove the EO, other volatile organic compounds (VOCs), and dissolved inerts.
G	Stripper. Waste gases, CO ₂ , VOCs, and inerts, are removed from the EO and purged through Vent B.
H	Refiner. Final polishing of EO.
<u>Stream</u>	
<1>	Primary reactor product gas. 1-2% EO.
<2>	Recycle ethylene gas stream.
<3>	Dilute aqueous solution of EO, CO ₂ , and other VOCs. Goes from the scrubbers to the EO finishing equipment.
<4>	Secondary reactor product gas.
<5>	Recycle water back to scrubbers.
<6>	Crude EO.
<7>	EO to refiner.

A description of the process equipment and streams is provided in Table XVI, and input, output information is summarized in Table XVII. The schematic and process description for EO and all subsequent processes was compiled from several references.^{91,92,93,94} In the following paragraphs, the letters, numbers, and vents in parentheses refer to Figure 2.

Table XVII. Description of Inputs and Outputs for the Air-based Ethylene Process

<u>Stream</u>	<u>Description</u>
Ethylene	Greater than 98% pure.
Inhibitor	Added to improve the selectivity of the catalyst. Reduces the conversion of ethylene to CO ₂ and water without impacting the reaction. Examples include chloroethane, and vinyl chloride.
EO	Ethylene oxide. Typically 99.5% pure.
Wastewaters	EO and water. Typically contains 8-10% EO, used as in the ethylene glycol process. Ethylene glycol and water. Typically treated and added to the ethylene glycol process.
<u>Vent</u>	
A	Main process vent. Potentially, the largest vent source. Contains purge CO ₂ , nitrogen, volatile organic compounds (VOCs), and other inert gases.
B	Stripper vent. Contains inert gases, ethylene and other VOCs absorbed in the main and secondary scrubbers.
C	Fugitive losses. Leaks from pumps, valves, compressors, etc.
D	Storage and loading losses. From storage tanks and transfer operations.
E	Wastewater losses. Volatilizing organic compounds from emergency wastewater ponds, and wastewater streams. The numerous wastewater streams from this process were not shown for simplicity.

EO is produced by passing ethylene and oxygen over a silver catalyst. In the baseline facility, ethylene, purified air, an inhibitor, and recycle gas are combined at an elevated temperature in a pressure reactor (B), 1-3 megapascal (MPa) to produce a reactor product gas stream <1> containing 1-2% EO. The EO and other contaminants are washed out of the gas stream in the primary scrubber (C). The waste gas <2> is divided and sent to both the primary and secondary reactor for recycling of the remaining ethylene. The main purpose of the secondary reactor (D) and scrubber (E) is to remove inerts in the system to prevent buildup through vent A. Water, EO, and contaminants are sent to the desorber (F) to have the water

removed <3> and then to the stripper (G) and refiner (H) to polish the EO. Some of the wastewaters from the process are sent to the EG plant for use and others (not shown) are sent to a biological wastewater treatment plant. The potential air emission points are the main process vent (Vent A), the stripper vent (Vent B), fugitive losses (Vent C), storage and loading losses (Vent D), and wastewater losses (Vent E).

The second portion of the Glycol II plant produces EG. A simplified schematic for production of ethylene glycol is shown in Figure 3. A description of the process equipment and streams is provided in Table XVIII, and emission vent information is summarized in Table XIX. Comments in parenthesis refer to Figure 3.

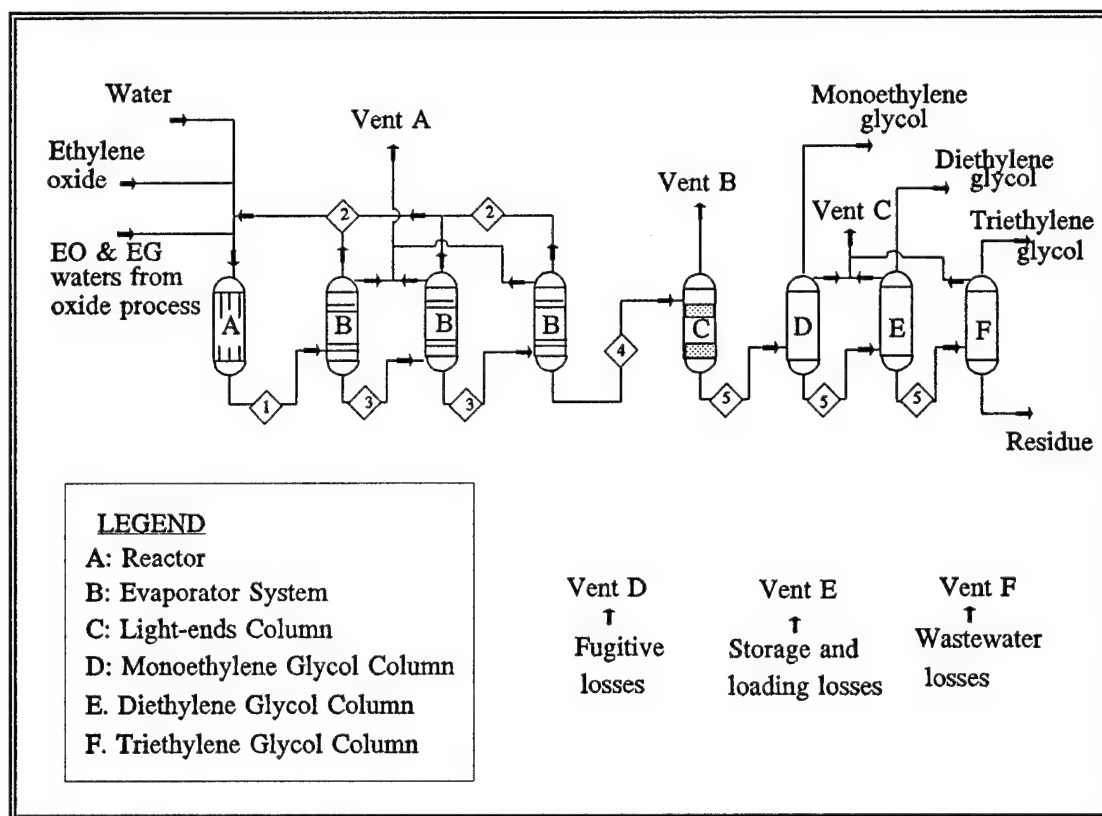


Figure 3. Ethylene Glycol Process

Table XVIII. Description of Equipment and Streams for the Ethylene Glycol Process

<u>Equipment</u>	<u>Description</u>
A	Reactor. Ethylene oxide (EO), water, wastewaters from the EO process and a water recycle stream are combined in a plug flow reactor at 190°C to 200°C and 1.4 MPa. The initial dilute solution contains 8 to 12 % EO by weight and sufficient residence time is provided to react all the EO in to monoethylene glycol (MEG) and small percentages of higher order glycols. Typical yield of MEG is approximately 88% by weight, 10% for DEG and 2.4% for TEG. Often production of TEG is promoted by varying feed ratios, reactor operation and other process variables.
B	Evaporator System. Remaining water is removed using a multiple-effect evaporator with progressively lower pressures.
C	Light-ends Column. Crude ethylene glycol (EG) is stripped of the remaining water and light impurities.
D	Monoethylene Glycol Column. Fiber grade MEG is distilled in a vacuum tower.
E	Diethylene Glycol (DEG) Column. High-purity DEG distilled in a vacuum tower.
F	Triethylene Glycol (TEG) Column. High-purity TEG distilled in a vacuum tower. The bottom residue contains heavier glycols and is burned as fuel or sold as by-products.
<u>Stream</u>	
<1>	EG and water from reactor.
<2>	Recycle water stream. Goes from the evaporators back to the reactor.
<3>	Progressively drier EG and water mixture.
<4>	Crude EG.
<5>	Remaining heavier fractions of EG.

EG is produced by thermally hydrolyzing EO without a catalyst and due to the reactivity of EO, essentially all is converted to EG. In the baseline facility, water, EO, and the EO, EG wastewaters from the oxide process are combined in a plug flow reactor (A) at elevated temperature and pressure. The reactor product <1> contains a dilute EG solution, the majority of which is monoethylene glycol (MEG), but progressively decreasing yields of diethylene glycol (DEG), triethylene glycol (TEG) and higher homologues are also produced. The solution is sent to the evaporator system (B) where the water is removed <2> in successive distillation columns using decreasing pressures. The crude EG <4> is cleaned of any remaining water and light

impurities in the light-ends column (C), and then the MEG, DEG, and TEG are separated by vacuum distillation (D,E,F). Several wastewater streams (not shown) are produced and sent to a biological wastewater treatment plant. The potential air emission points are the evaporator vents (Vent A), the light-ends column steam-jet ejector (Vent B), the distillation column ejectors (Vent C), fugitive losses (Vent D), storage and loading losses (Vent E), and wastewater losses (Vent F).

Table XIX. Description of Emission Vents for the Ethylene Glycol Process

<u>Vent</u>	
A	Evaporator vents.
B	Light-ends column steam-jet ejector. Contains water and light impurities.
C	Distillation column ejectors.
D	Fugitive losses. Leaks from pumps, valves, compressors, etc.
E	Storage and loading losses. From storage tanks and transfer operations.
F	Wastewater losses. Volatilizing organic compounds from emergency wastewater ponds, and wastewater streams. The wastewater streams from this process were not shown for simplicity.

The baseline facility consists of the air-based EO and the EG processing units. The EO process has five identified emission points and the EG process has six. Emission characteristics of these emission points is needed in order to develop HON implementation plans.

11.2.3 *Estimating Baseline Facility Air Emissions*

Estimating the baseline facility air emissions is presented in seven parts. Section 11.2.3.1, summarizes the data requirements and the four references used to meet the data requirements are listed in Section 11.2.3.2. Section 11.2.3.3 through 11.2.3.6 summarize the

information from each of the four references. In Section 11.2.3.7, the estimated baseline facility air emissions are presented.

11.2.3.1 Data Requirements In order to develop the RCT and ACS implementation plan for the baseline facility, air emissions and process data is necessary to determine compliance requirements under the HON rule. In order to determine compliance requirements for the RCT, enough information for each type of emission point is needed to determine whether it is Group 1 or 2. The specific requirements to delineate between Group 1 and 2 emission points - process vents, storage vessels, transfer racks, and wastewater stream - are summarized below. Information is only provided for existing facilities; the requirements for new facilities are more stringent.

Vents must meet three criteria to be classified as Group 1 process vents otherwise they are Group 2. The three criteria are: (1) flow rate greater than or equal to 0.005 m³/min, (2) total organic HAP concentration greater than or equal to 50 ppmv, and (3) total resource effectiveness (TRE) index value less than or equal to 1.0.²⁹ The TRE is calculated using Equation 22. If the necessary information is not available to calculate the TRE, the process vent can be assumed to be Group 1 and the appropriate compliance requirements met.

$$TRE = \frac{1}{E_{HAP}} \times [a + b \times Q_s + c \times H_T + d \times E_{TOC}] \quad \text{Equation 22}$$

Where:

E_{HAP}	-	Hourly emission rate of total organic HAP, kg/hr
Q_s	-	Vent stream flow rate, m ³ /min, at 20 C
H_T	-	Vent stream net heating value, MJ/m ³
E_{TOC}	-	Emission rate of TOC (minus methane and ethane), kg/hr
a, b, c, d	-	Coefficients in Table 1 of the HON rule that correspond to different control devices

Group 1 storage vessels are tanks whose volume is greater than or equal to 151 m³ and contain a HAP or combination of HAPs with an average vapor pressure greater than or equal to 5.2 kPa. Group 2 storage vessels are all other HAP containing tanks.

Group 1 transfer racks must load annually greater than or equal to 0.65 megaliters (ML) of liquid products that contain organic HAP with a weighted average vapor pressure greater than or equal to 10.3 kilopascals (kPa). The Group 2 transfer racks are all others.

A Group 1 wastewater stream has a total volatile organic HAP concentration of greater than or equal to 1000 parts per million, weight (ppmw) and a flow rate of 10 l/min or a HAP concentration of greater than or equal to 10,000 ppmw and any flow rate. A Group 2 wastewater stream is any process wastewater stream that does not meet the definition of a Group 1 stream. A wastewater stream as defined by the HON rule is an organic HAP containing water, raw material, intermediate, product, byproduct or waste material that exits a regulated processing unit.

Additional information is required on both Group 1 and Group 2 emission points in order to use the ACS method of compliance. Estimates of HAP emissions from all emission points is necessary to use Equation 1, introduced in Chapter IV and shown again below. The factors (0.02, 0.05) are the RCT efficiencies required on the Group 1 emission points.

$$E_A = 0.02 \times \sum EPV_1 + \sum EPV_2 + 0.05 \times \sum ES_1 + \sum ES_2 + 0.02 \times \sum ETR_1 + \sum ETR_2 + \sum EWW_{1c} + \sum EWW_2$$

Equation 1

Where:	E_A	=	Emission rate, megagrams per year, allowed for the source.
	$0.02 \sum EPV_1$	=	Sum of the residual emissions, megagrams per year, from all Group 1 process vents.
	$\sum EPV_2$	=	Sum of the emissions, megagrams per year, from all Group 2 process vents.
	$0.05 \sum ES_1$	=	Sum of the residual emissions, megagrams per year, from all Group 1 storage vessels.

ΣES_2	=	Sum of the emissions, megagrams per year, from all Group 2 storage vessels.
$0.02\Sigma ETR_1$	=	Sum of the residual emissions, megagrams per year, from all Group 1 transfer racks.
ΣETR_2	=	Sum of the emissions, megagrams per year, from all Group 2 transfer racks.
ΣEWW_{1c}	=	Sum of the residual emissions from all Group 1 wastewater streams.
ΣEWW_2	=	Sum of emissions from all Group 2 wastewater streams. ²⁹

11.2.3.2 References Four different types of reference sources were used to develop reasonable values for the baseline plant process data and air emission levels. First, information from the Glycol II plant at Plaquemine and HAP emission levels in 1986 was used. Second, emissions factors and related information was used from the EPA document "Locating and Estimating Air Emissions from Sources of Ethylene Oxide" (EO Pamphlet).⁹¹ These emission factors were developed from older EPA documents. Third, the EPA document, "HAP Emissions from Process Units in the Synthetic Organic Chemical Manufacturing Industry--Background Information for Proposed Standards, Volume 1C: Model Emission Sources" (Model Emission Source Document) was used to provide process vent data and some emissions information.⁸⁸ This reference, introduced in Chapter X, developed model emission sources from existing data from new sources performance standards (NSPS) for the SOCMIs and other related data. Fourth, chemical and environmental engineering references were used for specific data.

A chemical engineering reference was used to set a production level for the baseline facility in 1986. The facility is assumed to have a EO production level of 2.0×10^8 kg/yr or 220,000 tons/year because Ullmann's Encyclopedia of Industrial Chemistry states this was the production capability for the Dow Plaquemine EO plant in 1987.⁹² Ullmann's also indicates, typically 65% of EO is converted to EG. Therefore, the baseline facility's EG production level

is assumed to be 1.8×10^8 kg/yr or 200,000 tons/year after correction for change in molecular weight.

11.2.3.3 Glycol II Data Limited data was available from the Plaquemine Glycol II plant. Table XIX summarizes the air emissions from the plant reported in the Emission Inventory Questionnaire submitted to the Louisiana Department of Environmental Quality at the end of 1986.⁹⁵

Table XX. Emission Summary, Glycol II Plant at Plaquemine, 1986

Emission Point	Name of Pollutant	Annual Emission Rate, kg/yr
1. Heater 2, 4, 5	CO	5400
	NO ₂	1.0×10^5
2. EG storage tanks	HC ¹	6.4×10^4
3. Cooling tower	HC	1.4×10^5
4. Opening losses	HC	0
5. Fugitives	HC	6400
6. Expander	HC	3.7×10^4

Where: ¹HC - Hydrocarbons

Although, Table XX does not contain many of the emission points identified in Tables XVII and XIX, Facility Description, it is assumed Dow did not purposely omit emission points. The explanation for the discrepancies between the identified emission vents and the Dow reported emission points includes three possible factors. One, existing regulations had already limited emissions. For example, Louisiana State HAP emission control requirements required complete capture of EO emissions from storage tanks and transfer racks. Also, OSHA requirements limited the amount of EO that could be released because of toxicity and explosive hazards. Two,

Dow already had implemented several emission reduction projects at the plant to reduce wasted resources. Three, some emission points may have not been identified.

The first emission point, Heater 2, 4, 5, in Table XX is from the combustion of fuel gas in the heaters or boilers that provide the energy and steam for the various processes in the Glycol II plant. The second emission point, EG storage tanks, included ten tanks listed on the Emission Inventory Questionnaire which released total hydrocarbon emissions of 6.4×10^4 kg/yr. The facility was only required to test for hydrocarbons (HC) instead of conducting the more expensive laboratory tests to speciate the organic compounds. The third emission point, cooling tower, was a source of HC emissions because the Glycol II plant was sending some of the EG wastewaters and air emissions to the cooling tower water which subsequently vaporized. The fourth emission point, opening losses, were from maintenance and repair functions, and plant down time. The last emission point, the expander, is the EO main process vent, Vent A listed in Table XVII.

Little additional information was available about the Glycol II plant operations in 1986, therefore information was obtained from the 1993 Air Toxics Permit Application and other documents. In 1993, the plant listed 31 storage tanks as part of the EG production and storage and 7 storage tanks as part of the EO production. No EO was stored because it is used directly in the EG and other processes. Approximately one percent is sold as product. The tanks range in size from approximately 1.9 m^3 (500 gal) to 6000 m^3 (1,600,000 gal). All but one tank contains materials with an average vapor pressure under the Group 1 critical pressure of 5.2 kPa or 0.75 psia. One tank, approximately 640 m^3 (170,000 gal), contains heated crude glycol with a average vapor pressure of 1.7 psia (12 kPa). This tank released 4.3×10^4 kg/yr of HC of the 6.4×10^4 kg/yr listed for storage tanks in Table XX.

No information is available on the loading of EO or any emissions generated from the transfer from Glycol II plant to another process. A vapor collection system is used on many of

the EO processes and eliminates the air emissions from transfer operations. Assuming one percent is loaded (the amount sold as product), then a transfer rack loads 2.2 Ml/yr (2200 tons/yr) with a vapor pressure of 99.2 kPa at 10°C. EG is loaded into tank cars, tank trucks, and barges and ships with a transfer rack for each type of vehicle. Each transfer rack is estimated to load one third of the produced EG, approximately 550 Ml/yr (670,000 tons/yr) with a vapor pressure of 5.3 Pa for MEG at 20°C. The vapor pressure of DEG and TEG at the same temperature is 2.7 Pa and 0.5 Pa, respectively.

Very little information is available on the wastewater streams. In 1994, it was estimated that the Glycol II plant had one Group 1 and 19 Group 2 process wastewater streams. This does not include maintenance wastewaters and cooling water.

11.2.3.4 Ethylene Oxide Pamphlet Some process information and emission factors were available from the EPA pamphlet "Locating and Estimating Air Emissions from Sources of Ethylene Oxide".⁹¹ The information is only for the EO portion of the Glycol II plant and all emission rates calculated are only for EO and do not include the ethane, ethylene, acetaldehyde, formaldehyde, nitrogen, and CO₂ that are known by-products of this process. An uncontrolled emission factor (UEF) of 0.005 - 1 g/kg of EO produced was provided for the EO Vent A, main process vent. Using a production rate of 2.0×10^8 kg/yr and an UEF of 0.5 g/kg, gives an EO emission rate of approximately 1.0×10^4 kg/yr or 100 ton/yr. The pamphlet indicates that this emission source is typically burned in a thermal or catalytic oxidizer.

An UEF of ≤ 0.7 g/kg is provided for the EO Vent B, stripper vent. Using a value of 0.5 g/kg for the UEF gives the same EO emission rate of 1.0×10^4 kg/yr or 100 ton/yr. The pamphlet states this vent is normally combusted in a boiler.

An UEF of 2.6 g/kg is listed for the EO emissions from storing and loading operations. This value assumes the EO is stored under nitrogen in pressurized tanks (approximately 50 psi) at 16°C and 20% of the EO is loaded into tank cars. Using a value of 2.0×10^6 kg/yr of EO being stored and loaded (1%), yields an EO emission level of approximately 5000 kg/yr or 6 tons/yr. The pamphlet states these losses are assumed to occur only because of displacement during filling operations and usually these displaced vapors are either recycled to the process, scrubbed or incinerated.

Fugitive emissions which emanate from pump seals, compressors, valves, flanges, pressure relief devices and sample connections, were estimated at 188 kg of EO per day (approximately 400 lb/day). This value was estimated for a facility that was relatively uncontrolled and employed no measures for leak detection, repair and maintenance. Control Technology Guidelines (CTG) require a 38% reduction and the New Source Performance Standards (NSPS) require a 65-78% reduction in uncontrolled fugitive emissions. EO facilities have also significantly reduced fugitive emissions of EO in order to meet the OSHA standards due to the explosive hazard of the compound.

Only general information was provided on wastewater streams. The EO pamphlet stated that a few facilities used emergency holding ponds for diluting the EO in the process line during shutdown. Although wastewaters generally contain low levels of EO, high volatility allows the majority to evaporate.

11.2.3.5 Model Emissions Source Document The "HAP Emissions from Process Units in the Synthetic Organic Chemical Manufacturing Industry--Background Information for Proposed Standards, Volume 1C: Model Emission Sources" document provided some information on potential emissions from the process vents at the Glycol II plant. Three types of information;

process-specific, generic, and example model; are provided for three different process vents; EO vent A, EG vent A and EG vent C. Table XXI summarizes the information.

The air oxidation vent is the EO vent A. The distillation vent, vacuum (V) is the EG vent C and the distillation vent, nonvacuum (NV) is the EG vent A. Actual production process-specific values are given for Air Oxidation Vent #1, and Distillation Vent #1 and represent average values from a data base developed from the SOCMi NSPS background information documents (BIDs).⁸⁸ In comparison, the information listed under Distillation Vent #2V and #2NV represents values for generic process vents. This information is based on data from a range of processes because no specific process information was available in the SOCMi NSPS BIDs. Finally, the values used for Air Oxidation Vent #2, and Distillation Vent #3V and #3NV is from example model process vents developed to illustrate the potential emission reductions and cost impacts involved with controlling the process vents. These example models were developed from both the production process-specific and generic process data bases.

The Air Oxidation Vent #1 data is more representative of a typical EO facility because the values were developed from actual facility data. The Air Oxidation Vent #2 was used to develop impact numbers for the HON rule. Distillation Vent #1 is shown with no HAP emissions and it is assumed the actual facilities have some form of emission capture system from the EG vents. The other Distillation Vent HAP emissions are developed from averages of similar facilities and may not represent typical EG facilities.

The Model Emission Source document contains some information on transfer racks. Twenty model transfer racks, 10 for tank cars and 10 for tank trucks, were developed using information obtained from questionnaires sent out under Section 114 of the 1990 CAAA. The models relate rack size (number of loading arms) to the number of chemicals transferred at a given transfer rack and the total volume of chemicals transferred. Using the limited information

Table XXI. Vent Emission Information from the Model Emission Source Document

Characteristic	Air Oxidation Vent		Distillation Vent				
	#1	#2	#1	#2V	#2NV	#3V	#3NV
Production capacity (kg/yr) 10^6	64	320	120	85	130	82	36
Flow rate (m^3/min)	760	2700	0.74	0.74	0.91	0.71	0.26
Heat content (J/m^3) 10^6	0.22	0.90	0	4.5	28	4.5	28
Temperature ($^{\circ}C$)	130	-	38	32	43	-	-
Total VOC emission rate (kg/yr) 10^3	2900	-	0	13	350	-	-
HAP emission rate (kg/yr) 10^3	6.8	2800	0	6.6	290	6.4	8.5

on the transfer system at the Plaquemine Glycol II plant, none of the model transfer racks provide reasonable correlation. One of the better matches for loading EG is a model type for loading tank cars with 8 arms, with a maximum throughput of 0.0083 million gal/yr, an average vapor pressure of 0.021 mmHg and HAP emissions of 3.6×10^{-3} kg/yr. The Glycol II plant loads approximately 150 million gal/yr of EG into tank cars with a chemical vapor pressure of 0.04 mmHg (5.3 Pa).

The storage tank models are developed by type of tank, number of tanks, capacity, throughput, and chemical vapor pressure. The data used to develop the models came from EPA reports on organic chemical manufacturing and storage of VOCs. Because of the low vapor pressure of EG, all storage tanks are assumed to be of basic fixed roof design. The model that most closely matches the Glycol II plant assumes 10 tanks with a capacity of 2×10^6 gal, a throughput of 1.8×10^8 gal/yr, and a chemical vapor pressure of 0.13 psia. The resulting HAP emissions are 5.3×10^4 kg/yr. The Glycol II EG production is 4.3×10^7 gal/yr and the vapor pressure of EG is 7.7×10^{-4} psia.

The Document states that tanks containing liquids with high vapor pressures (above 29 psia) are assumed to have no emissions because of state regulations requiring pressurized tanks and emissions collection systems.

Specific wastewater stream information would be needed to use the estimated HAP emissions in the Model Emission Source document. Stream flow, facility flow, HAP concentration and the volatility of the compounds in the wastewater are needed. None of these are available on the Glycol II plant in 1986. This information is available on the wastewater streams for 1994 but the facility has undergone so many wastewater emission projects (discussed in Section 11.4) that the current data is not relevant to the baseline facility.

The same limitation occurs with estimating HAP emissions from equipment leaks or fugitive emissions because specific information is needed on types and number of sources, type of liquid and HAP concentration in each piece of equipment, and an idea of the complexity of the unit.

11.2.3.6 Engineering Manual Under EO in the Air Pollution Engineering Manual estimates of several emission points in the EO process are provided.⁹⁴ The Manual estimates 84.3 lbs of EO are emitted from Vent B for each ton of EO produced. This equates to 8.4×10^6 kg/yr of EO for the Glycol II plant. The Manual also estimates 2.74 lbs of EO per ton of EO production for storage losses. This equates to 2.7×10^5 kg/yr of EO.

11.2.3.7 Baseline Facility Air Emissions Using the information from the references, HAP emission values were estimated for the baseline facility. Additional process data needed for Sections 11.3 and 11.4 is taken from the summarized information from the references. The

emission values from the references are summarized in Table XXII. The selected baseline facility emission values are also shown.

Table XXII. HAP Emission Summary for Baseline Facility

Emission Sources	Glycol II Plant kg/yr	EO Pamphlet kg/yr	MES Document kg/yr	APE Manual kg/yr	Baseline Plant kg/yr
1. EO Vent A Main Process	3.7×10^4	1.0×10^5	2.1×10^4	-	3.7×10^4
2. EO Vent B Stripper	-	1.0×10^5	-	8.4×10^6	0
3. EG Vent A Evaporator	1.4×10^5	-	2.2×10^5	-	1.4×10^5
4. EG Vent B Light-end Column		-	-	-	
5. EG Vent C Distillation Columns		-	1.4×10^4	-	
6. Equipment Leaks or Fugitive Losses	6.4×10^3	6.9×10^4	-	-	3.8×10^4
7. EO Storage Tanks	-	-	-	2.7×10^5	0
8. EG Storage Tanks	6.4×10^4	-	1.3×10^4	-	6.4×10^4
9. EO Transfer Racks	-	5.0×10^3	-	-	2.5×10^3
10. EG Transfer Racks	-	-	65	-	65

The emission sources were identified in Section 11.2.2 Facility Description. Wastewater losses were not included in the table because no emission information was available. The emission values from the Plaquemine Glycol II plant are used to the extent possible, realizing that the facility had already reduced emissions at the facility and some emission points were not reported. To be conservative, the emission values from the Glycol II plant, which are for hydrocarbons, are assumed to be HAPs.

For emission point 1, EO Vent A, three emission values were found in the references. The Glycol II plant value was from the expander and the Model Emission Source (MES) Document value was from Air Oxidation Vent #1 scaled up for production capacity. Air Oxidation Vent #1 was used because the values came from actual representative facilities. All values were within one order of magnitude, therefore the value from the Glycol II plant was used.

For emission point 2, EO Vent B, two emission values were found. The EO pamphlet included a comment that this vent was usually combusted and the Air Pollution Engineering (APE) Manual value was high. It is assumed this vent is recycled or combusted at the baseline facility.

For emission point 3, 4, and 5, the EG vents, little information was available. The Glycol II value of 1.4×10^5 kg/yr is from the cooling tower and is assumed to be all the vented emissions from the EG process. Any other emissions from this process is assumed to be recycled or incinerated. A value is shown for both emission point 3 and 5 from the MES Document. The 1.6×10^5 kg/yr value for emission point 3 is an average of Distill Vents #2NV and #3NV emission values scaled up for production capacity. The value for emission point 5 is the value from Distill Vent #2V scaled up for size. The emission values from Distill Vents #2V and #3V are very similar when corrected for production capacity. The Glycol II emission value will be used for the baseline facility, although the flow data from the MES Document will be used to evaluate the TRE value in Section 11.3.

For emission point 6, equipment leaks, two values were found which differed by an order of magnitude. An emission value was available for the Glycol II plant and a worse case value was obtained from the EO Pamphlet for a facility with no control program. An average of the

two values was used for the baseline facility because the Glycol II plant had an equipment control leak program that may not be representative of the norm.

For emission point 7, EO storage tanks, the only available HAP emission value was from the APE Manual. It is assumed the baseline facility either has no EO storage tanks or pressurized tanks that do not emit HAPs.

For emission point 8, EG storage tanks, two similar values were found. An emission value was reported on the Glycol II plant and an emission value, scaled up for production capacity, was available in the MES Document. The value from the Glycol II plant was used for the baseline facility.

For emission point 9, EO transfer racks, an uncontrolled emission factor was used from the EO Pamphlet to estimate an emission value. This value represents both storage and loading of EO therefore the value was reduced by half to determine a value for the baseline facility.

For emission point 10, EG transfer racks, one value was found in the MES Document. This emission value, scaled up for production capacity was used for the baseline facility.

In summary, the final column in Table XXII lists the estimated HAP emission values for the 1986 baseline facility. The identified emission sources and the associated emission values are used to prepare the RCT implementation plan, Section 11.3, and the ACS implementation plan, Section 11.4.

11.3 RCT Implementation Plan

This section outlines a compliance program for the baseline facility by implementing the appropriate RCT. An abbreviated implementation plan is outlined by determining which emission points are Group 1, determining necessary control devices, and summarizing performance testing, monitoring, and paperwork requirements. Fugitive emissions are not evaluated because they are

regulated under Subpart H of the HON rule with significantly different requirements. The fugitive emission values are listed in some of the tables for comparison purposes. Wastewater streams are not addressed because sufficient information was not available to evaluate. The first sections of a HON Implementation Plan are a facility overview, list of emission sources, and basic emission source characteristics; this information was provided in Section 11.2.

11.3.1 Process Vents

In order to determine compliance requirements, the emission points must be segregated into Group 1 or Group 2. For the two process vents, the EO Vent A, and the EG Combined Vent, three values must be determined; the flow rate, HAP concentration and *TRE* as explained in Section 11.2.3.1. Table XXIII lists the values determined from the Glycol II plant data and the MES Document. Detail explanations and calculations of numbers in Table XXIII are provided in Appendix C.

For the EO Vent A, two sets of values are provided. The first is from the expander vent at the Glycol II plant, the second from the MES Document Air Oxidation Vent #1. The HAP concentration and *TRE* values are significantly different, indicating the model emission sources developed by the EPA may not be representative of all facilities. The values from the Glycol II plant will be used because the example is based on this facility. The flow rate of 2.3×10^3 m³/min exceeds the Group 1 cut off of 0.005 m³/min and but the HAP concentration level of 0.56 ppmv is less than the 50 ppmv Group 1 cut off value. The *TRE* is also greater than one, indicating the vent is to be classified as Group 2.

Four sets of values are shown for the EG Combined Vent. This represents emission sources 3, 4, and 5 in Table XXII. The first set of values is from the cooling tower at the Glycol II plant. The reason for the high flow rate and *TRE* is because the emission point data was

Table XXIII. Process Vents Group 1 - 2 Delineation

Process Vent	Data Source	Flow Rate m ³ /min	HAP Conc. ppmv	TRE Value	Group
EO Vent A Main Process	Glycol II	2.3×10^3	0.56	3.9	2
	MES Document	2.4×10^3	2.6	29	2
EG Combined Vent	Glycol II	1.9×10^4	0.10	14	2
	MES Document Evaporator	1.3	2.0×10^5	8.5×10^{-2}	1
	MES Document Distillation	1.6	4.7×10^4	1.1	1 or 2
	Average of MES	1.5	1.2×10^5	0.59	1

gathered after the HAPs were diluted with the water in the cooling tower. These values would not meet HON requirements and measurements would have to be taken prior to dilution. The second and third set of values are from emission source 3 and 5, respectively, in Table XXII. The difference between the HAP concentration and *TRE* values is probably due to the different types of equipment used. An average of the two sets of values from the MES Document is used to determine the Group 1 or 2 classification for this process vent. The values from the Glycol II plant can not be used and it is not known which of the two MES Document values more closely resemble the Glycol II vent. The EG Combined Vent meets all three criteria to be classified as Group 1.

A flare will be installed to meet the required 98% HAP reduction required for the Group 1 process vent. The EG Combined Vent emissions will be piped to the flare. As required by the HON rule, a thermocouple monitoring device, capable of continuously detecting the presence of a pilot flame will be properly installed, calibrated, maintained, and operated on the flare. Performance test requirements will be met. The reporting and recordkeeping requirements

for group and *TRE* determinations and performance tests, §63.117 of the HON, and the periodic reporting and recordkeeping requirements of §63.118 of the HON will all be met for the process vents.

11.3.2 Storage Tanks

Group 1 storage tanks are 151 m³ or larger in volume and contain HAP liquids with average vapor pressure greater than or equal to 5.2 kPa. Using the Glycol II plant data, summarized in Section 11.2.3.3, only one tank of the 38 tanks that are part of the facility is Group 1. This tank, 640 m³, contains heated crude glycol with an average vapor pressure of 12 kPa and emits 4.3×10^4 kg/yr of HC. The HC is assumed to be all HAP.

An internal floating roof will be installed inside the fixed roof to meet the RCT requirements. All operating and maintenance requirements will be met to reduce vaporization during filling. All inspection and repair requirements will be met and documented to meet the compliance determination requirements. All reporting and recordkeeping requirements will be performed. Recordkeeping requirements for Group 2 tanks will be met.

11.3.3 Transfer Racks

Group 1 transfer racks load at least 0.65 Ml/yr with an average vapor pressure of greater than or equal to 10.3 kPa. The EO is assumed to be loaded in a separate system, therefore the EO transfer rack is a Group 1 rack with 2.2 Ml/yr loaded and a vapor pressure of 99.2 kPa. EG has such a low vapor pressure, 5.3 Pa, the EG transfer rack is Group 2.

The EO transfer rack will be equipped with a vapor collection system and routed to the process vent flare. All requirements for proper loading operations into certified tank trucks

and/or railcars will be met. All requirements for inspection, maintenance, reporting and recordkeeping will be met.

11.3.4 RCT Emission Summary

Table XXIV summarizes the HAP emission reductions from implementing the RCT requirements. The total HAP emissions from the baseline facility, after the RCT implemented is 4.3×10^4 kg/yr.

Table XXIV. HAP Emission Reduction Using RCT

Emission Sources	Baseline Plant kg/yr	After RCT kg/yr
EO Vent A Main Process	3.7×10^4	3.7×10^4
EG Combined Vent	1.4×10^5	2.8×10^3
EG Storage Tank	6.4×10^4	3.2×10^3
EO Transfer Rack	2.5×10^3	50
Total	2.4×10^5	4.3×10^4

11.4 ACS Implementation Plan

This section outlines the HON compliance program for the Glycol II plant using the ACS instead of the RCT used in Section 11.3. The compliance requirements were determined by calculating the allowed emission rate, E_A from Equation 1, Section 11.2.3. The baseline plant HAP emission values from Table XXII and the Group determinations in Section 11.3 were used. The emission rates from the various emission sources are shown below. The E_A of 6.3×10^4 kg/yr is the amount of HAPs the baseline plant may emit and still be in compliance with the HON rule.

$$E_A = 0.02 \times \Sigma EPV_1 + \Sigma EPV_2 + 0.05 \times \Sigma ES_1 + \Sigma ES_2 + 0.02 \times \Sigma ETR_1 + \Sigma ETR_2$$

$$E_A = 6.3 \times 10^4 \text{ kg/yr}$$

Where:	ΣEPV_1	=	$1.4 \times 10^5 \text{ kg/yr}$
	ΣEPV_2	=	$3.7 \times 10^4 \text{ kg/yr}$
	ΣES_1	=	$4.3 \times 10^4 \text{ kg/yr}$
	ΣES_2	=	$2.1 \times 10^4 \text{ kg/yr}$
	ΣETR_1	=	$2.5 \times 10^3 \text{ kg/yr}$
	ΣETR_2	=	65 kg/yr.

11.4.1 Process Vents

Section 11.3.1, process vents, under the RCT implementation plan identified the EG Combined Vent at the baseline plant as Group 1 and the EO Vent A Main Process Vent as Group 2. Unlike the RCT approach, reducing the emission from these vents will be accomplished with programs that are, at least in part, pollution prevention projects. The first project significantly reduces the emissions from the EG Combined Vent. The second project was implemented to increase production capacity and reduce emissions. This project eliminated the emissions from the EO Vent A Main Process Vent, identified and eliminated emissions from an analyzer vent, and created and partially eliminated a CO₂ System Removal Vent. These projects were instituted at the Plaquemine Glycol II plant as part of Dow's Waste Reduction Always Pays (WRAP) program. The program encourages people within the facility to develop projects to reduce waste and energy usage. The projects are evaluated by a simple return on investment calculation and if implemented, the submitter receives an award. Although, Dow does not call these pollution prevention projects, some portion of all of them meet the basic tenant to reduce waste by modifying the process instead of installing pollution control devices.

The first project eliminates the HAP emissions from the cooling tower (EG Combined Vent in Table XXIII). The project includes modification to the EG cooling system to prevent the

air and wastewater emissions from venting through the cooling tower system. The exact details about the actual modification are not known. It is assumed half of the HAP emissions, 1.4×10^5 kg/yr, which were being emitted from the cooling tower are instead recycled back to the process, and the other half are incinerated in an existing boiler. This is a conservative estimate because references indicate most facilities recycle all these emissions.⁹³ The HAP emissions being incinerated are reduced 98% according to EPA efficiency rating.²⁹ EG Combined Vent emissions after the modification are 1.4×10^3 kg/yr.

This modification meets HON compliance requirements as long as the HAP emission stream sent to the boiler is introduced into the flame zone of the device. Although sending part of the emission stream to the boiler is not pollution prevention, the boiler was existing which saved money and half the emission stream was managed with pollution prevention through inline recycling. The Implementation Plan would include a detailed explanation of the modification.

The second project is a major modification to the facility from an air- to oxygen-based EO process. A simplified schematic of the reconfigured EO process is shown in Figure 4. A description of the process equipment and streams is provided in Table XXV, and input, output information is summarized in Table XXVI. The schematic and process description was compiled from several references.^{91,92,93,94}

Virtually all the differences between the air-based EO process and the oxygen-based process result from the difference in oxygen content coming into the reactor. Because there are fewer impurities in the oxygen feed than in air feed (i.e. nitrogen), the secondary reactor and scrubber are not necessary and there can be almost total recycling of unreacted ethylene. There is still a buildup of CO_2 in the system which could reduce the catalytic selectivity if not removed. A portion of the recycle gas from the EO scrubber (B) passes through a CO_2 absorber which uses potassium carbonate as an absorbent. The cleaned gas is returned to the reactor (A) and the spent

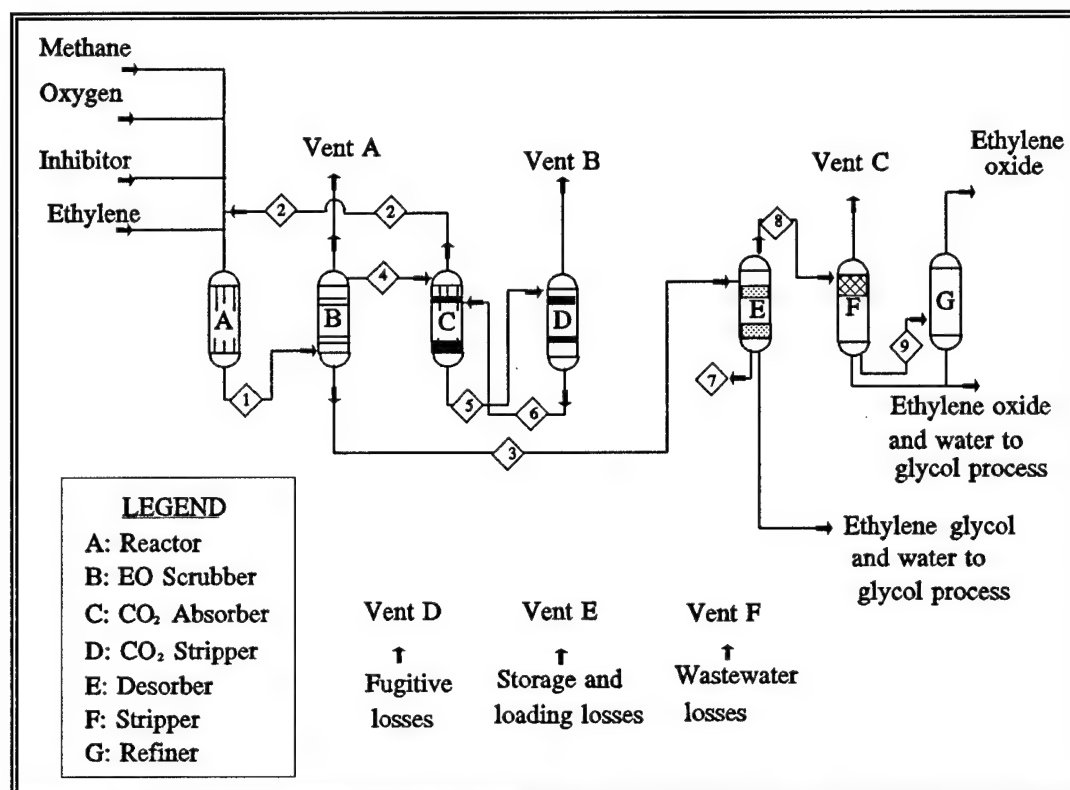


Figure 4. Oxygen-based Ethylene Oxide Process

CO₂ absorbent is reactivated in the CO₂ desorber. The EO polishing steps remain the same as do the fugitive, storage and loading, and wastewater losses.

At the Glycol II plant, the EO process was converted from air- to oxygen- based in 1990 to improve reactor yield while saving organic chemicals and fuel gas. The project included installation of a CO₂ removal system, and installation of a recovery unit to capture ethylene and other VOCs from the analyzer and expander vents. The expander vent was the Group 2 EO Vent A Main Process Vent, Table XXIII. The project also included removal of heater 2, which drove an air-based compressor, and installation of a system to capture the waste gases from the CO₂ removal system and vent them to an existing pipeline to fuel a steam generating boiler. The project essentially eliminated process vent emissions from the EO process.

Table XXV. Description of Equipment and Streams for the Oxygen-based Ethylene Process

<u>Equipment</u>	<u>Description</u>
A	Reactor. Ethylene, oxygen, and a recycled ethylene gas stream are combined and reacted over a silver catalyst packed in tubes. Conversion of ethylene to ethylene oxide (EO) is approximately 78%. Reaction temperature and pressure are maintained at 220°C to 280°C and 1 to 3 MPa. Reaction heat is dissipated by a jacket of heat transfer fluid. Inhibitors such as halides are added to suppress conversion of ethylene to CO ₂ and methane is added as a diluent. Small amounts of formaldehyde and acetaldehyde are formed as by-products.
B	EO Scrubber. Hot gas from the reactor is washed with cold water which dissolves the EO, some of the CO ₂ , and VOCs.
C	CO ₂ Absorber. Some of the gas exiting the EO scrubber (B), is sent to an absorber which uses hot aqueous potassium carbonate to absorb CO ₂ .
D	CO ₂ Stripper. Spent potassium carbonate absorbent is reactivated by steam and the cleaned gas is recycled to the CO ₂ absorber.
E	Desorber. The dilute aqueous solution from the EO scrubber is distilled under reduced pressure to remove the EO, other volatile organic compounds (VOCs), and dissolved inerts.
F	Stripper. Waste gases, CO ₂ , VOCs, and inerts, are removed from the EO and purged through Vent C.
G	Refiner. Final polishing of EO.
<u>Stream</u>	
<1>	Reactor product gas. 1-2% EO, 5-10% CO ₂ .
<2>	Recycle ethylene gas stream.
<3>	Dilute aqueous solution of EO, CO ₂ , and other VOCs. Goes from the scrubber to the EO finishing equipment.
<4>	CO ₂ purge stream.
<5>	Spent potassium carbonate absorbent to have CO ₂ desorbed.
<6>	Rejuvenated potassium carbonate absorbent.
<7>	Recycle water back to EO scrubber.
<8>	Crude EO.
<9>	EO to refiner.

The analyzer vents were from numerous small vapor sampling streams used to analyze the conditions in various EO process equipment. This emission source was not identified in the 1986 emission summary (Table XX) because it was unknown. The plant modification reduces

Table XXVI. Description of Inputs and Outputs for the Oxygen-based Ethylene Process

<u>Stream</u>	<u>Description</u>
Ethylene	Greater than 98% mole pure.
Methane	Added as a diluent. Raises the flammable limit and allows safe use of higher concentrations of ethylene and oxygen.
Oxygen	Greater than 97% mole pure.
Inhibitor	Added to improve the selectivity of the catalyst. Reduces the conversion of ethylene to CO ₂ and water without impacting the reaction. Examples include chloroethane, and vinyl chloride.
EO	Ethylene oxide. Typically 99.5% mole pure.
Wastewaters	EO and water. Typically contains 8-10% EO, used in the ethylene glycol process.
	Ethylene glycol and water. Typically treated and added to the ethylene glycol process.
<u>Vent</u>	
A	Main process vent. Contains purge argon, nitrogen, volatile organic compounds (VOCs), and other inert gases.
B	CO ₂ desorber vent. Contains CO ₂ and some nitrogen.
C	Stripper vent. Contains inert gases, ethylene and other VOCs absorbed in the scrubber.
D	Fugitive losses. From pumps, valves, compressors, etc.
E	Storage and loading losses. From storage tanks and transfer operations.
F	Wastewater losses. Volatilizing organic compounds from emergency wastewater ponds, and wastewater streams. The numerous wastewater streams from this process were not shown for simplicity.

HC (assumed to be HAP emissions) by 8.2×10^3 kg/yr. Additional emission points, listed in the 1993 Plaquemine Glycol II emission summary, but not included in the 1986 emission summary are discussed in Section 11.5.

All HON process vent compliance requirements are met by the air- to oxygen-based modification and sufficient design details would be included in the ACS Implementation Plan. The EO Vent A Main Process Vent (the expander vent) is now sent to a recovery unit and then recycled to the EO process with the recycle waste gas stream. The modification created a new

potential vent from the CO₂ removal system (Vent B in Figure 4). The emissions from this vent are being piped to the boiler which is incinerating the HAP emissions from the EG Combined Vent. One reference states the CO₂ Removal System Vent is more than 99.7% CO₂ and water, but also provides an UEF of 0.0006-0.75 g/kg of EO production.⁹¹ Using an UEF of 0.38 g/kg, yields a HAP emission rate of 7.6×10^4 kg/yr which is subsequently reduced 98% (EPA efficiency rating)²⁹ by incineration to 1.5×10^3 kg/yr.

This modification manages the EO vent and analyzer vents through pollution prevention but the CO₂ Removal System Vent is managed through end-of-pipe treatment, although the boiler was already in existence. The only compliance requirement is that the emission stream from the CO₂ Removal System Vent must be introduced into the flame zone of the boiler.

No monitoring or performance test requirements exist for the emissions streams managed by the pollution prevention projects since they are not released to the atmosphere. Monitoring requirements for the boiler depend on the specific boiler configuration, which is not known. If the boiler is less than 44 megawatts design heat input capacity, then a temperature monitoring device is required in the firebox, connected to a continuous recorder. If the vent streams are introduced with the primary fuel or are used as the primary fuel then the monitoring equipment is not required. Assuming monitoring equipment is required, then it will be installed, calibrated, maintained, and operated according to manufacturers specifications.

Performance test requirements for the boiler also depend on the exact configuration. No requirements exist if the boiler has a design heat input capacity of 44 megawatts or greater or if the vent stream is introduced with the primary fuel or is used as the primary fuel. Otherwise, the HAP emission stream must be measured before and after the boiler, following the requirements of §63.116 (c). It is assumed the performance tests are required for the baseline facility, and all requirements will be met.

The reporting, recordkeeping requirements for group and TRE determinations and performance tests, as defined in §63.117 will be met. Also, all the periodic reporting and recordkeeping requirements of §63.118 will be accomplished for the process vents.

11.4.2 Storage Tanks

Section 11.3.2, RCT Implementation Plan, Storage Tanks, identified one Group 1 storage tank. This tank contained heated crude glycol with an average vapor pressure high enough (12 kPa versus the Group 1 limit of 5.2 kPa) to be classified as Group 1. Rather than installing the RCT on this tank, a process modification was accomplished on the baseline facility. This project was accomplished at the Glycol II plant in 1990 and included adding a heat exchanger to the EO stripper (F in Figure 4) and redirecting several water and steam lines. Part of this WRAP - pollution prevention project was to reroute the feed line to the Group 1 tank through the heat exchanger before emptying into the tank. This lowered the vapor pressure in the tank to 0.68 kPa due to the glycol being cooled which reduced the HAP emissions to 1.2×10^3 kg/yr and changed the tank classification to Group 2.

Besides cooling the glycol in this tank, which reduced HAP emissions, this project included several other pollution prevention positives. The project eliminated the EO scrubber water blowdown and recovered EG that was going to the wastewater treatment plant. The project also recycled condensate, reduced the temperature of a wastewater stream, and upgraded the quality of a stream of EG. The only requirements for Group 2 tanks, under the HON regulation, is recordkeeping requirements which will be met.

11.4.3 Transfer Racks

The EO transfer rack at the baseline facility was identified as Group 1 in Section 11.3.3. The Glycol II plant was not emitting any HAPs from the EO transfer in 1986, Table XX, because the facility already had a vapor control system in place. The Glycol II data did not contain any projects for reducing emissions from the transfer rack.

For the ACS for the baseline facility, a vapor collection system will be installed on the EO transfer rack as was done under the RCT plan. Rather than incinerating the HAP emissions, they will be returned to the process. All requirements for proper loading, inspection, maintenance, reporting and recordkeeping will be met.

11.4.4 ACS Emission Summary

Table XXVII summarizes the HAP emission reductions and demonstrates compliance with the HON requirements. The total emissions from the baseline facility, after the ACS is implemented is below the allowed emission rate, $E_A = 6.3 \times 10^4$ kg/yr. Two emission sources were not identified in 1986: the analyzer vents which were previously unknown and the CO₂ Removal System Vent which was added with the plant modification.

The ACS incorporated several facility modifications to reduce emissions instead of installing pollution control devices. Not only did the modifications bring the facility into compliance with the HON, but additional benefits were achieved, i.e. increased production, resource and energy conservation. The benefits are further discussed in Chapter 12.

Table XXVII. HAP Emission Reduction Using ACS

Emission Sources	Baseline Plant kg/yr	After ACS kg/yr
EO Vent A Main Process	3.7×10^4	0
EG Combined Vent	1.4×10^5	1.4×10^3
Analyzer Vents	8.2×10^3	0
CO ₂ Removal System Vent	-	1.5×10^3
EG Storage Tank	6.4×10^4	1.2×10^3
EO Transfer Rack	2.5×10^3	0
Total	2.5×10^5	4.1×10^3

11.5 Issues at the Plaquemine Glycol II Plant

11.5.1 Introduction

The baseline facility provides an example of implementing both the RCT and ACS. At the actual Glycol II plant, additional pollution prevention modifications were accomplished and provide insight into the extent of pollution prevention changes that can be accomplished when an organization is so motivated. The additional plant modifications affecting air emissions are summarized in Section 11.5.2. The 1993 plant HAP emission summary, summarized and discussed in Section 11.5.3, barely resembles the 1986 summary. Section 11.5.4 discusses plant compliance with the HON wastewater requirements.

11.5.2 Pollution Prevention Plant Modifications

This section summarizes the additional WRAP projects implemented on the Glycol II facility, between 1986 and 1993, impacting air emissions and wastewater contents. Three WRAP

projects were already discussed in the ACS implementation plan. Seven projects are listed, letters in parentheses are references to Figure 4.

Project #1. In 1990, part of the EO desorber (F) and the EO refiner (G) were modified. The columns were changed from trayed to packed towers to reduce the pressure drop in the column and reduce the bottom temperature. This modification did not effect efficiency but did reduce EG formation which was being sent to the wastewater treatment plant.

Project #2. In 1992, a project was initiated to recover and recycle emissions from the EO analyzer vents. These vents are the end of numerous small sampling streams used to analyze the condition of the various processes. A header system was installed from the analyzer vents to a gas collection surge drum and then back to the EO scrubber (B).

Project #3. In 1992, a system was implemented to reclaim fugitive emissions from packing leakage from two compressors at the beginning of the EO process. The system returned methane and ethylene, that was being lost, back to the process.

Project #4. In 1992, a recovery flash drum system was installed on a wastewater stream that leaves the EO process and goes to the EG evaporator system (B in Figure 3) to have the EG removed. The flash drum system removes noncondensables in the wastewater system which have been reducing the efficiency of the evaporator column. The project recovered EG that was being sent to the wastewater treatment plant.

Project #5. In 1992, a condenser on one of the EG evaporator columns was repaired and upgraded. The condenser had been inoperative and allowed release of significant quantities of EG when the emergency vent on the evaporator column was used. The improved condenser collects the majority of the EG and returns it to the system.

Project #6. In 1992, the system to clean EO tank cars before refilling was modified. The old method of cleaning sent the wash water to the wastewater treatment plant. The new

system uses water from the EO scrubber (B) to wash the tank cars, then the wash water is returned to the process to capture the EO.

Project #7. In 1993, the old secondary scrubber from the air-based process was retrofitted to remove EO from the purge gas being sent to the CO₂ absorber. This modification allowed capture of EO before it was turned to EG in the CO₂ absorber system and then sent to the wastewater treatment plant.

11.5.3 1993 HAP Emission Summary

Because of the plant modifications and regulatory changes the HAP emissions reported in the 1993 Plaquemine Glycol II plant Air Toxics Permit application changed significantly from those in 1986, Table XX. The 1993 emission summary is shown in Table XXVIII.⁹⁰ In this summary, the list of emission sources is considerably longer than the list in 1986, and the HAPs have been speciated. The list is longer because many sources had not been identified or characterized in 1986. Additionally, some emission sources are new due to plant modifications and pollution prevention projects. The HAPs are speciated because of changes in the Louisiana environmental regulations. The values in parentheses refer to Figure 4.

Emission source #1, Heater 4 is a steam superheater fueled by fuel gas and waste gases from the CO₂ removal system (Vent B). This heater also burns emissions from other vents during a plant shutdown and has an overall HAP emission reduction efficiency of 98%.

Emission source #2, Fugitives, at 1.3×10^4 kg/yr are significantly higher than in 1986 (6.4×10^3 kg/yr). The higher value reflects a more thorough evaluation of fugitives in the plant. Between 1986 and 1993, the Glycol II plant underwent an extensive fugitive emissions evaluation and elimination program. For example, project #3 in Section 11.5.2. The higher value reported in 1993 actually represents a significant reduction in true overall fugitive emissions. The same

Emission source #4, Scrubber, is used to recover EO and EG from tank car washing, loading and repair operations, and storage tank vents. The equipment is rated at >99% efficient in HAP removal.

Emission source #5, Ejector vent #1, is an emergency escape valve in the EG production equipment. Emergency vents are excluded from HON requirements. Emissions are negligible because it is rarely used. Emission source #6, Column vent, is an emergency vent off a noncondensable vent from one of the EG distillation columns. (column C or D in Figure 3) Emission source #7, Emergency vent (LX), is from one of the EG storage tanks and other equipment.

Emission source #8 includes 30 EG storage tanks with total HAP emissions of 2.7×10^3 kg/yr compared to the 10 EG storage tanks listed in 1986 which emitted 6.4×10^4 kg/yr. The actual number of tanks at the facility did not change, the additional 20 tanks had not been identified as generating HAP emissions in 1986. The Group 1 tank that is a part of these EG storage tanks had its emissions reduced from 4.3×10^4 kg/yr to 1.2×10^3 kg/yr by the WRAP project discussed in Section 11.4.2.

Emission source #9 includes 10 other tanks, all Group 2, associated with the EO production. Several contain process waters and special cooling fluid but none contain EO. Emission source #10, Emergency vent (MO), is from the CO₂ removal system. Emission source #11, Barge and ship loading, is the MEG emissions from loading approximately one third of the EG product. This emission source is not regulated under the HON rule. Emission source #12, Waste heat vents, are process waste heat noncondensable vents.

Emission source #13, Vacuum pumps, are considered fugitive emissions under the HON rule. These pumps are part of the EG distillation process. Emission source #14, Sump, contains a small amount of wastewaters from the EG process. Emission source #15 is from loading EG

onto tank cars and tank trucks. The slight increase in emissions, from 65 kg/yr in 1986 to 100 kg/yr in 1993 is from increased plant production.

Emission source #16, Holding pond, catches rainwater runoff and any firefighting water. It is not regulated under the HON wastewater provisions. Emission source #17, Emergency vent (R4), is from Vent E in the EO process. Emissions are usually routed back to the process.

Emission source #18, Packing recovery vent, is the fugitive emissions from a compressor in the EO process. Emission source #19, Lab analysis equip., includes the emissions from sample drums, lab hoods, sample building hoods and other misc vents. These emissions are not regulated under the HON rule.

Total HAP emissions, not including the emission sources that are not regulated, regulated under Subpart H (equipment leaks) and the wastewater sources, are 8.3×10^3 kg/yr which is still less than the ACS allowed emission rate, $E_A = 6.3 \times 10^4$ kg/yr. The emission reduction is even more significant because more emission sources were identified and the plant increased production 21% since 1986.

11.5.4 Wastewater Compliance

Compliance with the wastewater requirements of the HON were not addressed with the baseline facility because no data was available to characterize the waste streams. Some information was available from the Glycol II plant by 1994 as they developed their HON compliance program.

The Glycol II plant is estimated to have 20 wastewater streams (depending on a point of generation clarification). Even with the WRAP plant modifications, one wastewater stream appears to be classified as Group 1. The HON requires emission control, water treatment, recordkeeping and reporting for Group 1 sources and recordkeeping for Group 2 sources.⁹⁶

RCT requirements include covering and vapor collection for some tanks, processes and streams, and HAP emission control using a steam stripper. Alternative control devices are allowed if they meet up to 99% mass removal efficiency (depending on the HAPS that are present). In response to public comments to industry, the HON regulation also allows use of biological treatment, with a 95% plus destruction efficiency required, instead of the listed RCTs. The majority of facilities regulated by the HON, including the Glycol II plant, use a biological wastewater treatment facility (biox) to handle facility wastewaters. These biow facilities typically obtain a HAP destruction efficiency of 50-90% depending on facility design and individual chemicals. It is doubtful any biow facility can achieve the 95% plus destruction efficiency required by the HON rule at this time.

At the Glycol II plant, the environmental engineers are considering installing a steam stripper or other RCT device at the Glycol II plant to treat the Group 1 wastewater stream. The other wastewater streams will continue to go to the biow facility. The Glycol II plant can not gain credit for all the emission reductions completed through the WRAP projects since emissions averaging excludes wastewater sources which are treated by a biow facility. Nor does the plant facility gain credit for the multi million dollar upgrade accomplished recently to the biow facility to make it state of the art.

The proposed ACS would allow the facility to document and use all the pollution prevention related HAP emissions reductions since 1987 and all other HAP emission reductions since 1990. If the ACS were part of the HON provisions, addition of the steam stripper would probably not be required.

11.6 Summary and Discussion

A EO/EG baseline facility was characterized using EPA pamphlets, engineering references, and information from the Dow Plaquemine Glycol II plant. HAP emissions were estimated for the emission sources although well justified information was limited.

Although the EO/EG source category is just one of many regulated by the HON rule, the limited HAP emissions and process specific data base raises the issue of whether the HAP emission data base is sufficient to support the current prescriptive, detailed regulatory requirements in the Title III regulations. The lack of available information is further justification for a more flexible, performance standard based regulation such as the ACS.

A RCT implementation plan, using control technologies, was developed. Development of the implementation plan was straight-forward, the emission sources were classified as Group 1 or 2 and the required control technologies were selected for implementation.

An ACS implementation plan was developed relying, in general, on pollution prevention projects from the Glycol II plant to reduce emissions. The example baseline facility demonstrated the application of the ACS. Other pollution prevention projects could have been used to meet the necessary emissions reductions but the projects implemented by the Glycol II plant were sufficient to meet the emission reductions required. The developed implementation plan demonstrated the ACS could be used to meet all HON emission reduction, paperwork and other requirements. Unlike the RCT requirements which dictate control technologies, the ACS allowed the facility to tailor its own compliance program with pollution prevention and other innovative approaches. The value of the ACS from a cost, risk reduction viewpoint is discussed in Chapter 12.

The ACS as proposed in Chapter 7 was applied to the example facility but the two special provisions were not. Provision 1, which permits credit for pollution prevention projects already

implemented, possibly could be used at the Dow Glycol II plant. It was not used at the baseline facility because the scenario was developed so all modifications to the facility were made in the present. If the Dow Glycol II plant determines additional emissions reductions are required, then they would benefit from Provision 1 because of their many pollution prevention projects previously accomplished. Provision 2, which permits incorporating other, unregulated, emission points into a compliance plan, would require a different scenario to evaluate. A more complex example would be required with some HON regulated process units and other units that were not expected to be regulated in the near future.

Major differences between the baseline facility and the Glycol II plant were discussed. Glycol II plant had incorporated additional pollution prevention projects to further reduce wasted resources. The plant also had a greater number of emission sources in its 1993 emissions summary because of more stringent regulatory requirements and a greater awareness.

It appears the HON rule does not require the Dow Glycol II plant to reduce HAP emissions except for the one Group 1 wastewater stream. The plant will have to complete extensive recordkeeping and reporting requirements. No emission reductions are required due to existing Louisiana regulations and proactive Dow environmental policy. If all facilities regulated by the HON rule or other Title III regulations were in similar condition, no Title III regulations would be required. Assuming all regulated facilities are not like the Glycol II plant, the ACS is a possible mechanism to encourage facilities to use pollution prevention projects to meet emission reduction requirements instead of pollution control devices. The use of the ACS is applicable to other Title III regulated facilities, although the exact details of the implementation plans would vary. The concept behind the ACS, design a flexible emission performance standard and then allow the facility to design its own compliance program, is transferable to other CAAA regulations and possibly other media regulations.

XII. Evaluation of Compliance Methods

12.1 Introduction

The Alternate Compliance Strategy (ACS), defined in Chapter 7, was applied to an example facility in Chapter 11. Both RCT and ACS implementation plans were prepared for the example facility to demonstrate how both compliance methods could be used to meet the required HAP emission reductions. With the data and information from the two implementation plans, the RCT and ACS is compared and evaluated.

Section 12.2 consists of the evaluation of the RCT, emissions averaging, and ACS method of compliance using the Evaluation Matrix developed in Chapter 8. Section 12.3 uses the Total Cost Assessment Model on the two implementation plans for an economic analysis and Section 12.4 evaluates the risk reduction between the two plans using the Risk Reduction Measurement Model of Chapter 9.

12.2 Criteria from Interested Parties

The two methods of compliance approved under the HON rule and the ACS are evaluated using the Evaluation Matrix presented in Chapter 8. The Evaluation Matrix has twelve criteria which were developed from the comments on the HON rule (Section 3.7) and EPA comments in the preambles to the proposed and final HON rule (Chapter 5). The score for each criteria ranges from 0-10 (ten optimum) for each compliance method and is shown in Table XXIX. The scoring is partially subjective, therefore the value of the score is to facilitate comparison between the three methods not necessarily the score given. The justification for each score is provided below. For three criteria, different scores are listed. The first score is from a regulatory perspective, the second from the regulated perspective, and the third an average of the two.

Table XXIX. Evaluating the Compliance Methods

Criteria	HON RCT	HON EA	ACS
1. Meets Statutory Requirements	10	10	10
2. Protect Human Health	8	8	9
3. Implementability - regulator	8	4	7
- industry	9	2	8
- average	8.5	3	7.5
4. Enforceability	10	6	8
5. Flexibility - regulator	7	8	10
- industry	6	6	7
- average	6.5	7	8.5
6. Simplicity	6	4	5
7. Administrative Impact	6	3	5
8. Cost - regulator	7	5	6
- industry	5	5	7
- average	6	5	6.5
9. Legal Survivability	9	8	8
10. Technology Advancement	4	5	9
11. Encourages Pollution Prevention	4	5	10
12. Fairness to Sources	3	2	5
Total Score	81	66	91.5

12.2.1 Meets Statutory Requirements

The first criteria in Table XXIX, Meets Statutory Requirements, shows all three compliance methods with a score of ten because all statutory requirements have been met. The EPA crafted the RCT and emissions averaging (EA) compliance methods to meet the Title III requirements. The ACS compliance methods is developed from the same requirements specified in the HON rule.

12.2.2 Protect Human Health

The HON RCT is scored with an eight because use of control technology to reduce emissions has been demonstrated to reduce emissions and protect human health. The score is not higher because the HON RCT does not regulate all emission sources at regulated facilities, nor does it mitigate secondary impacts of the required control technologies. The HON EA was given a score of eight because the same emission reductions are required plus pollution prevention is encouraged. Pollution prevention projects typically reduce overall environmental impacts more than control technologies for the same amount of emission reduction. The score was not higher because of the concern of interested parties that the complexity of EA would permit "gaming" by some facilities so as to not have to reduce emissions as much as the RCT would require. The ACS is given a score of nine because the same emission reduction must be met, pollution prevention is encouraged, and the compliance method is not as complex nor limited as the EA compliance method.

12.2.3 Implementability

From a regulators view point, the RCT is a familiar, straight-forward, implementable method of regulation and therefore is given an eight. The score is not higher because the requirements in the rule are complex and the paperwork required is extensive. The EA compliance method is scored a four because the regulators indicated in the comments they did not consider it very implementable. The EA method is more complex to regulate, does not mesh with some state programs, and is more paperwork intensive. The ACS is given a score of seven from a regulators viewpoint because it meshes well with existing state programs. Although the ACS is a new concept for regulating HAPs, existing compliance and pollution prevention efforts

at a regulated facility can be easily incorporated into the facility implementation plan. This concept was demonstrated with the baseline facility example and the efforts the Glycol II plant has undertaken to reduce emissions. The score is not higher because the ACS may face some of the skepticism and opposition to new ideas that the EA program received.

From a regulated industry viewpoint, the RCT is scored nine because it is a familiar type of regulation. If emission reduction is required, the appropriate pollution control device is installed. The score is not a ten because of the complex, paperwork intensive requirements. The EA is only given a score of two because the compliance requirements are extensive and the comments indicated very little support from the regulatory agencies suggesting an unwillingness to approve EA implementation plans. Demonstrating compliance may be difficult even though only a few emission points can be used. The ACS is given a score of eight from a regulated industry viewpoint because it is a straight-forward performance based standard. The allowed HAP emission rate is calculated from an equation and a compliance plan is developed. The score is not higher because pollution prevention projects and other innovative ideas maybe more difficult to get regulatory compliance approval since they are often new, complex, and require a greater process knowledge to understand. An average score for each compliance method is calculated for use in the total.

12.2.4 Enforceability

The Title III statutes were crafted to be enforceable. The HON RCT is scored a ten because it contains prescriptive, exact requirements for control, monitoring, performance and paperwork requirements. The compliance method is designed to facilitate the emission reduction verification and the levying of punishments for noncompliance. The EA program is scored a six because of the concerns over enforceability expressed in the comments and the increased

flexibility and paperwork of the compliance method. The ACS is scored an eight because the use of a performance standard method of compliance when compared to the EA credit/debit system will be easier to enforce. The score is not higher because the ACS encourages encompassing pollution prevention projects which may be more difficult to enforce due to their novelty and complexity.

12.2.5 Flexibility

From a regulators viewpoint, the RCT is scored a seven since the requirements are very rigid and specific. The regulation permits little adaptability for developing compliance programs that mesh with existing state programs. Some flexibility is permitted in selecting the control technology and setting up the monitoring program. The EA compliance method is scored an eight because by design, the program permits some flexibility although the scope is limited. The ACS is scored a ten because it allows regulatory agencies to develop mutually agreeable compliance strategies with regulated facilities that mesh with existing state programs, and incorporate innovative technologies. Since the scope is not limited, the compliance program can encompass large portions of the facility.

From a regulated industry point of view, the RCT rates a six because of the very limited flexibility of the compliance program. In general, the only flexibility afforded the facility is if the change does not affect the Group 1, 2 delineation of the emission sources nor change operations enough to trigger any of the required reporting provisions in the regulation. Otherwise, the facility has to go through a lengthy reporting, approval process. The EA is given the same score even though it is designed to increase compliance flexibility for the facility. The EA compliance method requires extensive documentation of the credit/debit program with little provision for varying the values through out the year. Coupled with the limited scope of EA,

the flexibility of the program is stifled. The ACS is given a score of seven from a regulated industry viewpoint because the compliance method was designed to allow flexibility in setting up a compliance program. The score is not higher because the ACS is constrained by the Group 1, 2 delineation and change of operations requirements in the HON. The current scope of the ACS is also limited to HON regulated emission sources and unregulated emission sources; flexibility would be significantly improved if the ACS eventually developed into a facility-wide program.

12.2.6 Simplicity

The HON rule is too complex for this score to be high. The RCT is scored six because the requirements are specified in a logical, sequential manner: determine sources; characterize as Group 1 and 2; implement control technology, monitoring, performance requirements, and paperwork programs. The EA program is given a score of four since the complexity of the credit/debit system and the accompanied paperwork. The sequential steps of the RCT are also required for the ACS so a score of five is given. The score is lower than the RCT method because the facility must develop and document its own compliance program which may require considerably more effort than installing specified control devices.

12.2.7 Administrative Impact

The CAAA creates a significant administrative burden on regulatory agencies and regulated industries, and Title III is no exception. The HON RCT is given a score of six due to the extensive paperwork requirements necessary to complete the implementation plan, recordkeeping, and other reporting requirements. The regulated industry must prepare and maintain this paperwork and the regulatory agency must review, approve, and enforce it. The

EA compliance method was given a score of three since the comments, from both regulator and regulatee, indicated the paperwork requirements would be considerably more involved than the RCT. The ACS is given a score of five due to extensive documentation requirements for the new pollution prevention projects. Reports and records would have to be completed by the regulated facility, and reviewed, and approved by the regulatory agency. Novel compliance approaches are more labor intensive to document than using the specified format and methods under the RCT requirements.

12.2.8 Cost

The HON RCT is given a score of seven from a regulators viewpoint. The regulation will be expensive to implement and enforce from an personnel standpoint, but Title V of the CAAA has provisions for potentially increased revenue for the regulatory agencies. The comments indicated the regulatory agencies felt the regulation would be expensive to manage, although the RCT is a familiar form of regulation. The EA is only given a score of five because the comments from the regulators indicated they expected a significant increase in cost for personnel to implement this program. The ACS is given a score of six; it is simpler than the EA program and should mesh well with existing state programs. The score is not higher because additional personnel and/or training maybe be needed to evaluate the pollution prevention and innovative projects in the ACS implementation plans.

The RCT is given a score of five from a regulated industry viewpoint because of the high cost of compliance, limited flexibility, and lack of acceptance of pollution prevention accomplishments. Wastewater compliance at the Dow Plaquemine Glycol II plant, discussed in Section 11.5.4, is an example. EA is given a score of six since the increased cost of the administrative requirements for the program will probably offset any cost savings from flexibility.

From a regulated industry viewpoint, the ACS is scored a seven because of the flexibility of the compliance method and the acceptance of pollution prevention accomplishments which can help to keep costs down. The cost issue is further addressed in Section 12.3.

12.2.9 Legal Survivability

The HON RCT scores a nine for its ability to survive judicial and political review. The RCT compliance method follows a format for regulating emissions that has been molded by twenty years of clean air regulation. Although the wastewater provisions are undergoing some challenge and the CAAA are receiving some political review with the new Congress, the regulation will probably stand in its current form. The EA compliance method scored an eight because of the claims in the comments that it was not legally defensible. The score would have been lower but the compliance method will not be used much and is therefore less likely to be contested. The ACS is given a score of eight because it would probably receive considerable judicial review since it is a novel approach to HAP emission regulation. The score would be lower except political and public support continues to increase for adoption of regulations that encourage pollution prevention.

12.2.10 Technology Advancement

The HON RCT is scored a four because it requires installation of existing control technology. Gaining approval for implementation of new technology is difficult and time consuming. The score would have been lower except the Group 1, 2 delineation encourages regulated facilities to incorporate measures to reduce sources below the Group 1 thresholds. The Dow Plaquemine Glycol II plant provides an example of a facility that implemented pollution prevention projects which eliminated or reduced Group 1 to Group 2 emission sources. The EA

is given a score of five since the compliance program can not be used on new sources, and only on a limited number of existing sources. The EA program could encourage a regulated facility to develop technology for an existing, limited application. The ACS is scored a nine. Facilities are given the option of developing the most advantageous, cost effective emission reduction, compliance program possible. Part of the reason the Dow Glycol II plant underwent the modifications was to save valuable resources and in doing so, designed and implemented pollution prevention projects. The score is not ten because gaining approval for new ideas will not be a simple process even with the ACS method.

12.2.11 Encourages Pollution Prevention

The HON RCT is scored a four because it does little to encourage and/or reward pollution prevention concepts and methods within the compliance program. The EA is given a score of five since it encourages pollution prevention in a narrow domain. The ACS is scored a ten since it was developed to encourage pollution prevention by rewarding past accomplishments and providing a compliance program that new pollution prevention projects can be incorporated within.

12.2.12 Fairness to Sources

The RCT is scored only a three because it is not fair to different sources. The requirements are different for new and existing facilities and there are minimum emission levels below which only limited requirements exist. Some small synthetic organic manufacturing facilities may avoid being a major source of HAPs and not have to meet the HON requirements whereas large facilities will exceed the major source criteria. The EA compliance program is less fair and given a score of two. The EA can only be used on a few existing sources and may only

be accomplishable by large companies since significant environmental management expertise and time will be required to implement. The ACS is scored a five since it can be used on new and existing sources, with no limit on the number. Provision 2 allows other emission sources to be incorporated into the ACS compliance program. The score is not higher because the ACS is constrained by the HON structure which made the RCT unfair. The ACS may also be unfair to small companies that do not have the environmental management staff to develop and implement a pollution prevention compliance program.

12.2.13 Total Score

A total score is shown from the sum of the individual scores for the criteria and the averages where applicable. The score is of limited value since some of the criteria should be weighted indicating their increased significance over other criteria. For example, the CAAA history indicates enforceability is more important than fairness to sources. The value of the total score is to demonstrate that the ACS should be given strong consideration as an alternate compliance method and incorporated into Title III regulations.

The low score of the EA compliance method reflects its limited value due to the narrowing of the scope between the proposed and final regulation as was discussed in the HON Rule Evolution (Chapter 5). Many of the basic tenets proposed in the original EA program designed to encourage pollution prevention and flexibility have been adopted into the ACS.

A more accurate completion of the Evaluation Matrix requires implementation and use of ACS and EA. Questionnaires could be sent to regulators, regulated industry personnel, and other interested parties for their opinion. Before implementation of the ACS, some validation of the numbers in Table XXIX could be obtained by soliciting interested parties, familiar with the HON, to study the ACS and make evaluations.

The Evaluation Matrix can be used to evaluate other regulations and possibly statutes. The Matrix incorporates the concerns of the three main parties involved in many environmental regulations - the regulated party, environmental groups, and regulators. The Matrix could be used for other Title III regulations, some of other CAAA regulations and other media regulations.

12.3 Total Cost Assessment

12.3.1 Introduction

The second evaluation of the compliance methods will apply the Total Cost Assessment (TCA) Model discussed in Section 8.3. This financial/economic evaluation method is used to compare the ACS compliance method on the baseline facility with the RCT compliance method. The TCA provides a more thorough financial evaluation of pollution prevention options than traditional methods.

The extended cost inventory for the RCT method of compliance for the baseline facility is listed and discussed below followed by a similar analysis for the ACS. Then, the TCA long-term financial indicators for both methods of compliance are listed and discussed. The tier analysis system, discussed in Section 8.3.2.5, was not used because of the limited available cost information. All values are baselined as of January 1994. When maintenance costs are not available, they are estimated as 2% of capital costs as suggested by EPA "Waste Minimization Opportunity Assessment Manual".⁴

12.3.2 Extended Cost Inventory for RCT Compliance Method

Table XXX shows the costs and benefits associated with implementing the RCT on the baseline facility as outlined in Section 11.3. The list in Table XXX is not as extensive as the list

of potential TCA costs and benefits in Table VII. Additional information, particularly for the hidden and liability costs was not available.

Table XXX. Extended Cost Inventory for RCT Compliance Method

Costs and Benefits	Dollars (\$K)
1. Direct costs	
Flare - capital expenses	-1,000
Flare - annual expenses	-1,800
Flare - overhead, insurance	-180
Internal floating roof - capital expenses	-22
Internal floating roof - annual savings	5
Vapor collection system - capital expenses	-300
Vapor collection system - annual expenses	-15
2. Hidden costs	
Flare - monitoring device	-5
Total capital costs	-1300
Total costs	-3300

The first entry under direct costs, flare, was installed to control the HAP emissions from the EG Combined Vent and the vapor control system installed on the EO Transfer Rack. The cost information on the flare came from an example cost estimate of a typical flare in the EPA Handbook "Control Technologies for Hazardous Air Pollutants".⁹⁷ The capital expenses include equipment and installation, and annual expenses include fuel, electricity, steam, and operating and maintenance labor costs. The piping used to transport the HAP emissions from the sources to the flare was estimated using a "Means Square Foot Costs" estimating guide.⁹⁸

The internal floating roof was installed on the Group 1 storage tank to meet RCT requirements. The cost information for the internal floating roof was estimated using equations and factors in the EPA pamphlet "Hazardous Air Pollutant Emissions from Process Units in the Synthetic Organic Chemical Manufacturing Industry--Background Information for Proposed Standards, Vol. 1B: Control Technologies" (Vol 1B: CT).⁹⁹ The capital expenses include cleaning the tank and installing a new floating deck. The annual benefit includes maintenance and operating costs plus the value of the saved EG and EO emissions. The value of the chemicals was estimated from the Dow Plaquemine Glycol II plant WRAP project documents.

The vapor collection system brought the EO Transfer Rack into compliance. The cost information for the vapor collection system was estimated from several sources. The cost for converting a loading rack from top loading to bottom loading was estimated using the Vol 1B: CT.⁹⁹ The cost to retrofit tank and rail cars was assumed to be incorporated into the fleet management program. The additional capital expenses of piping and fan were estimated using "Means Square Foot Costs" and "Means Building Construction Cost Data".^{98,100} Annual costs were estimated from factors in the Vol 1B: CT and utility costs from the flare.

Total capital and cost figures are shown and are used in the TCA evaluation. The values in Table XXX may not be a precise representation of the costs to implement the RCT on the baseline facility because of limited cost estimating information. Considerable research could be done to gather cost information from industry and manufactures of the RCT equipment to develop cost estimating guides.

12.3.3 Extended Cost Inventory for ACS Compliance Method

Table XXXI shows the costs and benefits associated with implementing the ACS on the baseline facility as outlined in Section 11.4. The list of costs and benefits includes limited hidden costs and no liability costs because cost estimating information was not available.

Table XXXI. Extended Cost Inventory for ACS Compliance Method

Costs and Benefits	Dollars (\$K)
1. Direct costs	
Modify cooling tower - capital expenses	-40
Modify cooling tower - annual expenses	-280
Change EO process to oxygen-based - capital expenses	-1,700
Change EO process to oxygen-based - annual savings	1,300
Modify process for storage tank - capital expenses	-670
Modify process for storage tank - annual savings	250
Vapor collection system - capital expenses	-300
Vapor collection system - annual expenses	-9
2. Hidden costs	
Boiler - monitoring device	-5
WWTP savings	120
Total capital costs	-2700
Total costs	-1300

The first entry in Table XXXI, modify cooling tower, reduced emissions from the EG Combined Vent by recycling half of the HAP emissions back to the process and incinerating the other half in an existing boiler. Capital expenses to install the emission handling system was estimated using "Means Square Foot Costs".⁹⁸ The annual savings were estimated by calculating

the value of the recycled chemicals. The annual cost to incinerate half the HAP emissions in the boiler was estimated by scaling the annual costs from the flare.

Changing the EO process from air- to oxygen-based eliminated the HAP emissions from the EO Vent A Main Process Vent and the EG Combined Vent. The change introduced a new emissions source, the CO₂ Vent that was routed to an existing boiler for incineration. The cost information for the project came from Dow Plaquemine Glycol II plant project documents. Capital expenses include equipment and installation. Annual savings include the value of the saved ethylene and the cost of increased electricity usage and maintenance labor.

The process modification that changed the Group 1 storage tank to Group 2 is called the T-5 Bayonet Exchanger project in the Dow Glycol II plant WRAP projects. The modification affected several waste streams discussed in Section 11.4.2. Capital costs include equipment and installation. Annual savings include estimates for condensate saved, EG recovered, and EG upgraded. Utilities and maintenance costs are subtracted.

The vapor collection system installed on the EO Transfer Rack is the same system used under the RCT compliance method except the captured EO emissions are returned to the process. The annual costs include the value of the saved EO.

Under Hidden Costs, the monitoring device for the boiler is required to meet the monitoring requirements for incinerating the HAP emissions from the EG Combined Vent and the CO₂ Vent. The wastewater treatment plant (WWTP) savings are the reduced cost for treating wastewater streams from the baseline facility after implementing the pollution prevention projects.

No attempt was made to estimate hidden compliance costs like reporting, training, recordkeeping, and permitting for either the RCT or ACS compliance methods. For both methods, these costs will be very similar under the HON rule. Although the ACS may reduce

paperwork requirements for emission points that were eliminated, additional justification will be required to explain the ACS emission reduction programs.

In order to estimate liability costs, information would be necessary on typical costs for citizen suits and regulatory fines for HAP emissions and inadvertent releases. Some facilities many have historic data on these costs but none was available in the literature. The EPA "Pollution Prevention Benefits Manual" provided some guidelines for estimating liability costs from water pollution and hazardous waste disposal and releases but they were not designed for application to CAAA issues.⁶² Liability costs for the ACS may be lower than the RCT compliance program because more HAPs are reused in the process instead of incinerating and releasing to wastewater.

The baseline facility may receive some less tangible benefit from the ACS program through increased revenue from enhanced company and product image from the pollution prevention projects. However, determining a value to a company for environmentally friendly programs is difficult.

12.3.4 TCA Evaluation of RCT and ACS Compliance Programs

Table XXXII summarizes the costs from the extended cost inventory tables and includes the long-term financial indicators. The TCA evaluation spreadsheet is included in Appendix D. The format used is presented in the EPA "Waste Minimization Opportunity Assessment Manual."⁴ A time horizon of ten years was used and operating costs were assumed to be 20% of capital costs. Double-declining depreciation allowance was used and an inflation or escalation rate of 5% was assumed. Revenues were assumed to be \$20,000,000 for the baseline facility and the income tax rate was assumed to be 34%. The net present value (NPV) and the profitability

indicator (PI) was calculated using a 10% cost of capital interest rate. Results of other cost of capital rates are included in Appendix D.

The \$1,300,000 total capital cost of the RCT compliance program is less than half the \$2,700,000 total capital cost of the ACS program. But the ACS program saves money on an annual basis with savings instead of annual costs like the RCT. The NPV is the present value of all in- and out- cash flows, discounted at the project's cost of capital. The best economic investment is the project with the highest NPV. The values are high because a high revenue value was assumed. The ACS has a higher NPV (\$91,097) because, the ACS has an annual savings and a high capital cost. The RCT has a lower NPV (\$79,067) because of the high annual costs.

Table XXXII. TCA Evaluation - Long-term Financial Indicators (10 Year Life)

Financial Data Summary	RCT	ACS
Total capital costs	\$-1,300,000	\$-2,700,000
Annual costs or savings	\$-2,080,000	\$838,000
Net present value	\$79,067	\$91,097
Internal rate of return	9.2%	5.2%
Profitability indicator	56	32

The internal rate of return (IRR) is the discount rate that equates the present value of a project's cash inflows to the present value of the costs. A project is considered a good investment when the IRR is greater than the cost of capital. Ten percent was used as the cost of capital for this evaluation, therefore neither RCT or ACS is a good investment. But the baseline facility is not considering implementing the RCT or the ACS for investment reasons. Using just

the IRR financial indicator, the RCT is a better investment with a higher IRR of 9.2 than the ACS at 5.2.

The PI is the ratio of the present value of benefits divided by the present value of costs and the highest value indicates the best investment. The PI indicates the RCT is the better investment with a PI of 56 versus the ACS at 32.

Relying on just the financial indicators, choosing between the RCT and ACS would be difficult. The NPV indicates the ACS is a better investment whereas the IRR and PI indicate the RCT is better. The TCA documents indicate the NPV is the preferred method of selecting the project which implies the ACS should be selected.^{60,11} Dow also felt the ACS projects were worthy of implementing. The EO process conversion from air- to oxygen-based also increased production. The exact amount of increase is not available because Dow considers the information confidential. If the production increase is factored into the TCA evaluation, further justification would be given toward selecting the ACS compliance method. The financial indicators would be vary if more of the extended cost inventory values were known. The indicators also change if different assumptions were made, i.e. the cost of capital, but the relative values of indicators when comparing the RCT and the ACS did not change for several iterations of values.

The TCA Model is a valuable tool for conducting a thorough financial analysis of different compliance options. Considerable effort is required to gather the necessary cost and savings values. A tiered analysis, although not used here, may assist in limiting the data gathering to only the information necessary to conduct the evaluation. The financial indicators for this baseline facility demonstrate an interesting point - in some cases pollution prevention projects may not be good investments. For the baseline facility, the owner will be tempted to go with the RCT because of potentially less regulatory hassles instead of deciding on the compliance method that reduces emissions the most. (Section 11.4.4 demonstrates the ACS

reduces HAP emissions more than the RCT.) But, the ACS is the better investment, increases production, and reduces more HAP emissions to the environment.

12.4 Risk Reduction Measurement

12.4.1 Introduction

Risk has been a traditional concern with HAPs, and although Title III was developed to rely on technology based pollution controls, comments indicated the risk questions must be addressed especially for innovative compliance strategies. The Risk Reduction Measurement Model, developed in Chapter 9, will be applied to the example facility to evaluate the risk reduction between the RCT and ACS compliance programs. The purpose is not to conduct a thorough risk assessment of potential control options, instead to evaluate whether the different compliance programs provide similar risk reductions to the community.

In Section 12.4.2 the HAP emissions in Chapter 11 are speciated so the risk reduction calculations can be accomplished. Sections 12.4.3 and 12.4.4 apply the risk reduction model to the HAP emissions remaining after the RCT and ACS compliance programs have been implemented, respectively. Section 12.4.5 compares the risk reduction between the two compliance programs.

12.4.2 HAP Chemical Speciation

In Section 11.2.3.7, the baseline facility was developed with four regulated emission sources. The total estimated HAP emissions from each emission source from Table XXII are listed again in the first column of Table XXXIII. Before proceeding with the risk reduction evaluation, the HAP emissions must be speciated into chemicals emitted with the associated

concentrations. Measured speciation of the emission sources is not available and will be estimated. The Dow Plaquemine Glycol II plant permit application reported total hydrocarbons (HC) and the other references used to develop the baseline facility reported total HAPs. The speciation of the HAP emissions is estimated using the speciated HAP emission summary for the Glycol II plant from 1993, Table XXVIII.

The emissions from the first emission source, EO Vent A Main Process Vent, listed in Table XXXIII, were speciated using the chemical ratios of emission source #10, Emergency Vent (MO), Table XXVIII. Emission source #10 is from the CO₂ removal system (Figure 4) and most closely resembles the expected emissions from the EO Vent A Main Process Vent. The CO₂ removal system does not affect emissions but contains a process stream similar to the air-based EO process. The calculated emission values are shown in Table XXXIII. These concentrations are probably high because the total emission value from Glycol II data was for HC not HAPs. A portion of the HC being emitted from this vent is ethylene, a process feedstock, which is not a HAP. No data is available on the percentage of the HC that is ethylene so the total HC emission value is used for the total HAP emission value to be conservative. This error is probably not significant in the other emission sources because the HCs emitted are almost entirely HAPs.

The emissions from EG Combined Vent, the second emission source, were speciated using emission source #13, vacuum pumps, Table XXVIII. The vacuum pump emissions are from the EG distillation process and are representative of those expected from the EG Combined Vent. The emissions from the EG Storage Tanks were speciated using emission source #8, EG Storage tanks. Emissions include compounds besides EG since several tanks contain crude glycol. The emissions from the EO transfer rack are assumed to be all EO because the produced

Table XXXIII. Speciation of Chemicals for Emission Points at Baseline Facility

Emission Source	Total kg/yr	Acet ¹ kg/yr	Form ² kg/yr	MEG ³ kg/yr	EC ⁴ kg/yr	EO ⁵ kg/yr	1,4-DO ⁶ kg/yr
1. EO Vent A Main Process Vent	3.7×10^4	1.7×10^4	0	0	2.0×10^3	1.8×10^4	0
2. EG Combined Vent	1.4×10^5	3.2×10^3	420	1.1×10^5	0	2.0×10^4	9.5×10^3
3. EG Storage Tanks	6.4×10^4	9.4	9.4	4.7×10^4	0	1.7×10^4	470
4. EO Transfer Rack	2.5×10^3	0	0	0	0	2.5×10^3	0
Totals	2.4×10^5	2.0×10^4	430	1.6×10^5	2.0×10^3	5.8×10^4	1.0×10^3

Where: ¹ Acet - Acetaldehyde
² Form - Formaldehyde
³ MEG - Monoethylene glycol
⁴ EC - Ethyl chloride
⁵ EO - Ethylene oxide
⁶ 1,4-DO - 1,4-Diethylene oxide

EO is 99.5% pure. Total emissions for each chemical is shown and used in the risk reduction measurement.

12.4.3 Risk Reduction Measurement Evaluation - RCT Compliance Method at Baseline Facility

Table XXXIV lists the HAPs from Table XXXIII with the appropriate weight of evidence, *SF* and *RfC* values. A data confidence level is included. The risk assessment data was found in EPA Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (HEAST).^{80, 86, 78}

The first risk reduction evaluation will determine $\Delta Risk$ and ΔHQ using the original emissions from the baseline facility and the emissions after RCT has been installed. The evaluation is shown in Table XXXV. Q_i is the total emission value from Table XXII converted from kg/yr to mg/sec. Acetaldehyde and formaldehyde are listed twice because both carcinogen and noncarcinogen risk assessment data was available. $Risk_i$ was calculated using Equation 15

Table XXXIV. Risk Assessment Data for Baseline Facility

HAP	WoE ¹	SF ² kg-day/mg	RfC ³ $\mu\text{g}/\text{m}^3$	Data Confidence
Acetaldehyde	B2	7.7×10^{-3}	9	RfC confidence is low. Inhalation SF.
Formaldehyde	B1	4.6×10^{-2}	700	RfC converted from oral RfD. Inhalation SF.
Ethylene glycol			7×10^3	RfC converted from oral RfD.
Ethyl chloride			1×10^4	RfC confidence is medium.
Ethylene oxide	B1	0.35		Inhalation SF, from HEAST.
1,4-Diethylene oxide	B2	1.1×10^{-2}		Oral SF.

Source: IRIS, HEAST

Where: ¹ WoE - Weight of evidence
² SF - Slope factor
³ RfC - Inhalation reference concentration

and HQ_i using Equation 17 (Chapter 9). Q_2 , the concentration being emitted after RCT was installed, was calculated by reducing the total emission values in Table XXII by the percent reduction achieved by the respective control technologies. The HAP emissions from the EO Vent A Main Process Vent, a Group 2 vent, were not changed. Whereas the EG Combined Vent which is a Group 1 vent had HAP emissions reduced 98% by installing a flare. The Group 1 EG Storage Tank emitted 4.3×10^4 kg/yr of the 6.4×10^4 kg/yr HAP emissions from all the EG Storage Tanks. The emissions from the Group 1 tank were reduced 95% by installing an internal floating roof. The Group 2 storage tank emissions were unchanged. The EO Transfer Rack emissions were reduced 98% by installing a vapor collection system and routing the emissions to the flare.

All the $\Delta Risk$ was from ethylene oxide and although the weight of evidence is B1, the SF is suspect because no information was available on EO in IRIS, only HEAST which is less reliable. Q_1 may be outside the reasonable range in which to use the SF but HEAST does not

Table XXXV. Estimating Change in Risk, Using RCT on Baseline Facility

HAP	Q_1^1 (mg/sec)	$Risk_1^2$	Q_2^3 (mg/sec)	$Risk_2^4$	$\Delta Risk^5$
Acetaldehyde	630	2×10^{-3}	540	2×10^{-3}	0
Formaldehyde	14	3×10^{-4}	0.38	7×10^{-6}	-3×10^{-4}
Ethylene oxide	1.8×10^3	0.3	790	0.1	-0.2
1,4-Diethylene oxide	32	1×10^{-4}	12	5×10^{-5}	-5×10^{-5}
$\Delta Risk_{Total}$	-0.2				
		HQ_1^6		HQ_2^7	ΔHQ^8
Acetaldehyde	630	70	540	60	-10
Formaldehyde	14	0.02	0.38	5×10^{-4}	-0.02
Ethylene glycol	5.1×10^3	0.7	630	0.09	-0.6
Ethyl chloride	63	6×10^{-3}	63	6×10^{-3}	0
ΔHI	-10				

- Where:
- ¹ Q_1 - Original concentration being emitted
 - ² $Risk_1$ - Estimated risk associated with Q_1 , Equ. 15
 - ³ Q_2 - Concentration being emitted, after RCT
 - ⁴ $Risk_2$ - Estimated risk associated with Q_2 , Equ. 15
 - ⁵ $\Delta Risk$ - Change in risk, Equ. 18
 - ⁶ HQ_1 - Estimated hazard quotient associated with Q_1 , Equ. 17
 - ⁷ HQ_2 - Estimated hazard quotient associated with Q_2 , Equ. 17
 - ⁸ ΔHQ - Change in hazard quotient, Equ. 19

provide reasonable ranges. The Q_i s for acetaldehyde and formaldehyde are within reasonable ranges. It is irrelevant whether or not Q_i for 1,4-diethylene oxide is within reasonable range because the SF is from oral data and of limited value.

The only case where $HQ \geq 1$ is from acetaldehyde which has a value of 70. This value is suspect because Q_i is above the recommended range for using with the RfC and the RfC confidence is low. The only other HQ near one is from EG. This value is very suspect because the RfC was converted from an oral RfD .

12.4.4 Risk Reduction Measurement Evaluation - ACS Compliance Method at Baseline Facility

The second risk reduction evaluation determines $\Delta Risk$ and ΔHQ using the original emissions from the baseline facility and the emissions after the ACS projects were implemented. The evaluation is shown in Table XXXVI. Q_1 is the same total emission value from Table XXII. Q_2 , the concentration being emitted after implementation of the ACS program, was calculated by speciating the HAP emissions listed in Table XXVII under the column, "After ACS". The conversion of the EO process from air- to oxygen-based, eliminated the EO Vent A Main Process Vent emissions but introduced a new vent, the CO₂ Removal System Vent that emits 1.5×10^3 kg/yr of HAP. This emission value was speciated using the same chemical ratios used to speciate the EO Vent A Main Process Vent. The emissions from the EG Combined Vent were reduced to 1.4×10^3 kg/yr using a partial recycle, partial incineration program. The HAP emissions were speciated in the same manner as the original EG Combined Vent emissions. Emissions from the Group 1 storage tank were reduced to 1.2×10^3 kg/yr by process modification. Remaining emissions were speciated like the original EG Storage Tank emissions to yield total EG storage tank emissions. The remaining Group 1 emissions were added to the unchanged Group 2 storage tank emissions. The EO Transfer Rack emissions were eliminated by installing a vapor collection system and recycling the vapors.

12.4.5 Comparison of Risk Reduction for RCT and ACS

The $\Delta Risk_{Total}$ value is -0.3 and -0.2 for the RCT and ACS compliance programs, and the ΔHI value is -10 and -70 for the RCT and ACS program, respectively (Table XXXV and XXXVI). The lower $\Delta Risk_{Total}$ and ΔHI values for the ACS compliance program indicate a greater risk reduction over the RCT program because of additional HAP emission reductions.

Table XXXVI. Estimating Change in Risk, Using ACS on Baseline Facility

HAP	Q ₁ (mg/sec)	Risk ₁	Q ₂ (mg/sec)	Risk ₂	ΔRisk
Acetaldehyde	630	2 × 10 ⁻³	24	7 × 10 ⁻⁵	-2 × 10 ⁻³
Formaldehyde	14	3 × 10 ⁻⁴	0.24	4 × 10 ⁻⁶	-3 × 10 ⁻⁴
Ethylene oxide	1.8 × 10 ³	0.3	220	0.03	-0.3
1,4-Diethylene oxide	32	1 × 10 ⁻⁴	8.6	4 × 10 ⁻⁵	-6 × 10 ⁻⁵
ΔRisk _{Total}	-0.3				
		HQ ₁		HQ ₂	ΔHQ
Acetaldehyde	630	70	24	3	-70
Formaldehyde	14	0.02	0.24	3 × 10 ⁻⁴	-0.02
Ethylene glycol	5.1 × 10 ³	0.7	570	0.08	-0.6
Ethyl chloride	63	6 × 10 ⁻³	0.86	9 × 10 ⁻⁵	-6 × 10 ⁻³
ΔHI	-70				

The $Risk_2$ and HQ_2 values differ between the tables and also indicate the ACS compliance program is lower risk. The main reason for the difference in risk reduction is the air- to oxygen-based EO process conversion that eliminated emissions from the EO Vent A Main Process Vent in the ACS program. The Risk Reduction Measure Model demonstrated, for this example, the ACS reduced risk a greater amount than the RCT program. For the baseline facility, the ACS compliance program should be accepted as at least equivalent in risk reduction to the RCT program and arguably better. The ACS program also reduced HAP emissions to wastewater streams, which were not evaluated because of a lack of data. These reduced HAP emissions provide further justification of the value of the ACS.

The Risk Reduction Measurement Model is applicable to many air emission reduction evaluation scenarios. The Model is based in engineering principles and provides a fairly simple evaluation of the magnitude of risk reduction between different compliance options. The Model

could be just to address risk issues for many CAAA programs, particularly Title III. For example, in the final HON rule, if a facility elects to use the emissions averaging compliance method then the owners of the facility must demonstrate their emissions averaging does not increase the risk in comparison to the required RCT. The Risk Reduction Measurement Model can be used for the required risk comparison. It may also be valuable at the local regulatory level in evaluating compliance alternatives.

The main limitation of the Model is that it relies on available risk data which is often of questionable accuracy. As was demonstrated in this exercise, for several chemicals, inhalation risk data was not available and some of the inhalation data was suspect. As risk values from further research in inhalation risk become available, the accuracy and value of the Risk Reduction Measurement Model will increase.

12.5 Summary

Three evaluations were completed using methods developed earlier. The evaluations relied on data and information from the example facility and compared the ACS to the compliance methods in the HON rule. The Evaluation Matrix, TCA Model and Risk Reduction Measurement Model are fairly simple, have wide application, and were developed to address concerns from interested parties.

The evaluations demonstrated for this example facility, the ACS compliance program is at least as valuable as the RCT and should be accepted. The argument can be made that the ACS compliance program at the example facility is better. The ACS scores were considerably higher than any of the HON rule compliance methods in the Evaluation Matrix. Although the values are somewhat subjective, many were justified for the example facility. The TCA evaluation showed that the NPV for the ACS program was higher and Risk Reduction evaluation indicated

the ACS reduced risk more than the RCT compliance program. Additional conclusions and recommendations are presented in Chapter 14.

XIII. Summary

The major accomplishment of this dissertation was the development and demonstrated use of an alternate compliance strategy (ACS) that incorporates pollution prevention to replace the traditional end-of-pipe control strategy which historically has been used to gain compliance with environmental regulations. During the course of the ACS development, it was necessary to evaluate and draw from the tenets of many studies, programs, philosophies and observations that assisted in the process.

Background information was provided on the EPA pollution prevention program (Chapter 2), the Clean Air Act Amendments (CAAA) (Chapter 3), and regulatory shortcomings (Chapter 4). The pollution prevention program was defined and several EPA programs were introduced. Speeches and documents prepared by key administration personnel were discussed indicating the need to pursue pollution prevention actions in regulations. The difficulties of implementing pollution prevention in regulations and industry activities were discussed.

Since the ACS was developed around the Hazardous Organic National Emissions Standards Hazardous Air Pollutants standards (HON rule), considerable background information was provided on the history of HAP regulation, and the 1990 CAAA with emphasis on Title III and the HON rule. The limited pollution prevention concepts, the Group 1, 2 delineation provisions and the emissions averaging program in the HON rule were discussed. A lengthy treatise on the public comments from the HON rule was provided to illustrate the various opinions on flexible, innovative forms of regulation. In general, the National Resource Defense Council was opposed to innovative forms of regulation and felt the HON should be more stringent. State regulators wanted assurance the HON rule compliance methods were implementable, enforceable, and verifiable. Industry was concerned with cost and compliance requirements which are simple, flexible, and implementable.

Three studies were reviewed to provide guidance on current regulatory limitations and recommendations to improve the current regulatory programs. All three studies were sponsored or conducted by the EPA and indicated pollution prevention should be encouraged in regulations through flexibility and performance based standards. The studies also indicated a need for more willingness to try new methods of environmental management and for increased cooperation between the interested parties; i.e. regulators, regulatees, environmental groups, and the public.

Attempts the EPA made in incorporating pollution prevention concepts into the HON rule and the difficulties encountered were discussed in the HON Rule Evolution (Chapter 5). The emission averaging program and other suggested provisions in the proposed HON rule were designed to be flexible and encourage pollution prevention. The flexible and innovative provisions in the final HON rule were limited due to of the many negative comments received and the EPA's historic perspective and experience in writing, implementing, and enforcing rules.

The Netherlands National Environmental Policy Plan (NEPP) was studied to obtain new ideas for incorporating into environmental regulations (Chapter 6). The NEPP program establishes key environmental quality objectives, develops long term programs of action, and sets pollution reduction targets for key sources in a integrated cross-media approach. Under examination, the Netherlands environmental policy appears to be more flexible and have a more cooperative, interactive philosophy, but does not specifically encourage pollution prevention.

The ACS is defined by converting language in the HON rule into a performance based standard so a regulated facility can calculate its allowed HAP emission rate (Chapter 7). The facility can then design a compliance plan to meet the allowed rate. The ACS encourages innovation and pollution prevention by permitting flexibility in meeting emission reduction requirements. In general, the ACS can be used to meet the HON requirements by incorporating the same emission reductions, and similar monitoring, performance testing, and reporting

requirements. The ACS also includes two additional provisions; one to reward past pollution prevention efforts and therefore encourage new projects. The second provision encourages expansion of the scope of the pollution prevention effort within the facility.

An Evaluation Matrix is developed to qualitatively compare the HON and ACE compliance methods (Chapter 8). Twelve criteria are selected from the comments on the HON rule and EPA input on the HON rule evolution. The Matrix allows each compliance method to be given a score ranging from one to ten (ten optimum) with justification.

The Total Cost Assessment Model is synopsized from an EPA sponsored quantitative financial/economic evaluation method (Chapter 8). The TCA is a comprehensive, long-term financial analysis of pollution prevention projects and other options by using environmental data, appropriate time horizons, and standard financial indicators.

A Risk Reduction Measurement Model is presented that evaluates the magnitude change in risk from changes in the quantities and/or types of pollutants released (Chapter 9). This fairly simple, yet comprehensive Model provides a method of insuring pollution prevention compliance programs are as protective of human health and the environment as traditional end-of-pipe control technology. The Risk Reduction Measurement Model is based on EPA risk assessment guidelines and engineering principles to estimate pollutant dispersion. Exposure pathway, toxicity, and carcinogenic/noncarcinogenic issues are discussed. Use of the Model is demonstrated with three examples: evaluating change in risk from a RCT compliance program, comparing change in risk from RCT and pollution prevention control options, and comparing change in carcinogenic risk to change in noncarcinogenic risk.

An example facility was needed to demonstrate the use of the ACS and enable the evaluation of the compliance methods (Chapter 10). Criteria were developed for selecting a

facility and fourteen potential companies contacted. The Dow Plaquemine Glycol II plant was selected as the optimum example facility.

The Dow Glycol II plant was in compliance with the HON requirements, therefore an example baseline facility was characterized. The baseline ethylene oxide (EO), ethylene glycol (EG) facility was developed using information from chemical engineering references, EPA documents and information from the Dow Glycol II plant. After the HAP emissions from the baseline facility were estimated, a RCT implementation plan was developed that instituted required control technology on the Group 1 emission sources. An ACS implementation plan was developed based on the allowed HAP emission rate. The ACS exceeded the required emission reduction by implementing several plant modifications some of which had been accomplished at the Dow Glycol II plant. A considerable portion of these modifications and programs are classified as pollution prevention. Additional information was provided on issues at the Dow Glycol II plant including other pollution prevention plant modifications, the 1993 HAP emission summary, and a discussion of wastewater compliance.

The RCT and ACS compliance programs were evaluated using the Evaluation Matrix, the Total Cost Assessment Model, and the Risk Reduction Measurement Model. The Evaluation Matrix was scored for both compliance methods in the HON regulations and the ACS. The results indicated the ACS was the preferable compliance method using twelve criteria. The RCT placed second and the emissions averaging program third. The ACS scored the most points in protecting human health, flexibility, cost avoidance, technology advancement, encouraging pollution prevention, and fairness.

In the TCA evaluation, extended cost inventories were developed for the RCT and ACS implementation plans and the financial indicators calculated. Extensive information was not available to conduct a complete TCA and some available cost information was suspect. For

example, the reduced liability savings from the pollution prevention programs could not be estimated. The Net Present Value financial indicator implied the ACS was the preferred compliance program.

The Risk Reduction Measurement Model was used to compare the magnitude of the risk reduction after implementing the RCT and the ACS compliance program. The accuracy of the values from the Model was limited by the quality of available risk data. For example, only oral exposure route risk data was available on 1,4-Diethylene oxide and ethylene glycol. The Model demonstrated the ACS compliance program reduced both carcinogenic and noncarcinogenic risk by a greater amount than the RCT program. The greater risk reduction of the ACS was directly related to the greater reduction of HAP emissions in the pollution prevention based compliance program. If the risk reduction from the reduction of HAPs in the wastewater streams from the ACS pollution prevention programs could have been quantified, then the ACS would have demonstrated even greater risk reduction.

XIV. Conclusions and Recommendations

14.1 Alternative Compliance Strategy Goals

The goal of this research, to develop and demonstrate an alternate compliance strategy that incorporates pollution prevention, flexibility, and encourages innovative technology, was achieved. The ACS provides flexibility through a performance based standard that is derived from the HON rule, allowing regulated facilities to develop their own compliance programs. Pollution prevention and innovative technology is encouraged indirectly by permitting the facility to design, test, and implement new emission reduction programs, and directly by two special provisions. Past pollution prevention accomplishments are rewarded and pollution prevention programs are encouraged which encompass as much of the facility as the HON regulation will allow.

The ACS was applied to an example facility and the resulting pollution prevention implementation plan demonstrated that HAP emissions were reduced more than the required amount. The ACS compliance program at the example facility also recycled HAP emissions instead of incinerating or releasing them to wastewater, and increased the production capability of the facility. The RCT implementation plan, relying on end-of-pipe control technology, only reduced HAP emissions by the required amount. The example application demonstrated the ACS was feasible for this scenario, straight-forward, met all other HON requirements, and permitted flexibility and innovation in the development of the compliance plan. There is no reason to doubt that the scenario will be equally applicable to other industrial facilities.

The Evaluation Matrix comparison qualitatively demonstrated the ACS is at least comparable to the RCT compliance method, and arguably preferable. The Total Cost Assessment (TCA) conducted on the example facility indicated the ACS was the preferred investment. The

Risk Reduction Measurement Model demonstrated the ACS compliance program reduced risk a greater amount than the RCT compliance program.

14.2 Additional Comments

The ACS was built on the proposed emissions averaging program; a compliance option of the proposed HON rule that permitted flexibility, and encouraged pollution prevention. The emission averaging program in the final rule no longer fit that philosophy, but sections in the HON rule were used to form the basis for the ACS. The ACS was designed to build on the positive sections of the emission averaging program. For example, the credit/debit system received many negative comments ranging from too complicated, easy to game, paperwork intensive, and difficult to enforce. The ACS was developed to mitigate some of the negative concerns with a simple performance based standard that should mesh with existing state regulations and compliance programs at the facility. The original ideas of allowing the emissions averaging program to be used on as much of the facility as possible and methods to reward pollution prevention accomplishments were also carried into the ACS.

The trepidation the chemical companies demonstrated at sharing information for participation in the research is disturbing. The concern over divulging confidential information limits participation in other research ventures and severely limits any pollution prevention technology transfer. The EPA has a pollution prevention technology transfer program that attempts to overcome some of these barriers. A possible alternative solution is in Dow's approach to market its environmental successes. Recently Dow Chemical formed an environmental management subsidiary, Dow Environmental Inc., which can be used by other companies as a consultant agency. In the future, small or inexperienced firms may be able to contract with a similar company that has an extensive pollution prevention program and pay for

the transfer of relevant pollution prevention technology. If the regulatory agencies accepted and encouraged the ACS concept, which provides a mechanism to incorporate new ideas into compliance programs, this form of pollution prevention technology transfer might flourish.

Reviewing the Dow Plaquemine Glycol II plant documents, the increase in knowledge of emissions over the past ten years was phenomenal. An example is the difference between the plan emission summary in 1986, Table XX, and the emission summary in 1993, Table XXVIII. The actual 1993 emission summary was considerably longer, but was condensed for brevity. The environmental management personnel had identified, characterized, and often subsequently reduced the emissions from almost ten times more emission sources. This increased knowledge was due in part to state regulatory requirements and to an increased environmental awareness by the company.

During the development of the example facility and the subsequent application of the Total Cost Assessment Model, the lack and poor quality of available data was evident. The data available on the EO, EG process, emission sources and characteristics, control options, and cost and impacts of control was reviewed. In general, the data is outdated, sometimes extended back to the 1970's, incomplete, and in part unsubstantiated. Since the EPA is using this data to write regulations, some effort should be expended to update this data. Good regulations cannot be written from poor emissions data. This problem furthers the need for regulations to be written as a performance standard which regulated facilities have to meet, instead of prescriptive requirements that are developed from outdated data. It is recommended the EPA should focus its attention on developing performance standards, incorporating the ACS to encourage pollution prevention, and developing acceptable methods to measure, verify and enforce pollution prevention and innovative programs.

The TCA on the example facility demonstrated an interesting point. At many facilities the simple, inexpensive pollution prevention projects have already been accomplished. In order to take the next step, develop and invest in the next generation of pollution prevention projects, additional encouragement may be necessary. Regulatory support of pollution prevention projects through programs like the ACS would provide the incentive. For example, if the owners of the example baseline facility were making the choice between the ACS and RCT compliance programs, but there was no ACS option, the owners might decide against implementing the pollution prevention program. There would be little confidence the pollution prevention compliance program would be accepted by the regulatory agency and the pollution prevention program is not a good investment. The RCT compliance program would possibly be implemented over the pollution prevention program even though the later reduces HAP emissions to a greater extent, saves resources, and increases production capability.

14.3 Value

The ACS should be incorporated into the HON rule and other similar Title III regulations as an alternative method of compliance. The ACS provides a major step in the progression of moving regulations from the traditional end-of-pipe treatment philosophy to pollution prevention performance based standards. It meshes with the HON rule and existing state programs, and is simple and straight-forward. Combined with the evaluation methods, the ACS not only can be used to effect compromise between the divergent opinions on pollution regulation but serve as a tool to ameliorate opposing viewpoints of highly opinionated environmental groups.

The basic philosophy of the ACS can be incorporated into most environmental regulations by determining a performance standard that regulated facilities have to meet and then allowing them to design their own compliance programs. The ACS can be adapted to most Title III

regulations with little modification. The specifics of the ACS may have to be modified to be used in other 1990 CAAA regulations and other media regulations.

Eventually, environmental regulation should move to a total facility approach, like the Netherlands environmental program. Then the facility could determine its performance standard for the entire facility and design a pollution prevention program to reduce emissions to the extent possible. The ACS is the first step towards the total facility approach.

The value of the ACS can be viewed from various directions. Perhaps the only facilities that would take advantage of the ACS are the larger firms with existing pollution prevention programs, because of the increased environmental management staff required. Then the ACS would become a vehicle for these larger firms to develop and implement innovative programs. After trial and acceptance, then the innovative programs could be sold to smaller firms through the pollution prevention consultant program mentioned in the previous section or distributed through the EPA technology transfer program.

The evaluation methods have considerable merit of their own. The Evaluation Matrix encompasses the range of concerns from interested parties on environmental regulations in twelve criteria. The Matrix could be used by the EPA to evaluate other regulations and new or different alternatives. The Matrix could be used by other interested parties i.e. environmental groups or regulated industry to address limitations of proposed regulations or programs.

The use of the TCA Model also demonstrated the value of the method to compare different compliance options even when limited data is available. The application and improvement of the TCA should be encouraged and expanded.

The Risk Reduction Measurement Model has widespread application in evaluating the risk reduction that is possible from air pollution emission reduction programs. The Model is simple, based on engineering principles, and in essence compares chemicals by toxicity values. The

Model can be used by environmental managers to evaluate which emission reduction programs reduces risk the most and by regulators as a new method for insuring public safety. For example, the requirement in the HON rule for a risk evaluation if the emissions averaging program is used could be changed to require the use of the Risk Reduction Measurement Model. If the ACS was adopted, then a clause could be added that the regulated facility would have to demonstrate, using the Model, that the risk was reduced to a level comparable to that of the RCT compliance method. The Risk Reduction Measurement Model is a comprehensive method to demonstrate pollution prevention options are as protective of human health as traditional end-of-pipe control technology.

14.4 Recommendations for Future Research

The value and feasibility of the ACS was demonstrated at an example facility in this dissertation and the strategy may now be ready to be incorporated in Title III regulations. But before this can be done, additional information may be needed and can be attained through future research efforts. First, the viability and usefulness of the ACS could be demonstrated by surveying the public, industry, EPA, academia, and various environmental groups. A survey package could be developed that explained the ACS and then asks questions about the ACS and the other HON compliance methods. The gathered data could be used to verify the scores in the Evaluation Matrix. Second, industries to be regulated under future Title III regulations could be contacted to act as pilot plants for further testing of the ACS. Since the ACS was demonstrated to have several benefits over the RCT compliance method in the example facility, i.e. greater risk reduction, better investment, and increased production, industry may be more willing to participate in this endeavor than in the past. Data obtained from the pilot plant research could further demonstrate the utility and value of the ACS at an actual facility. This research effort

could document the efficacy of the ACS in the positions of the public, industry and EPA and lead to the incorporation of the ACS into the HON, other CAAA regulations, and eventually other media regulations.

Finally, since the adoption of the pollution prevention ethic nationwide will necessarily force a culture change in the total environmental community, the ACS can possibly become the trigger in moving the country from the traditional end-of-pipe technology culture to one based on pollution prevention.

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Abbreviations/Glossary

ACS - Alternate compliance strategy. Proposed alternate approach to compliance which incorporates pollution prevention, and flexibility, while encouraging innovative technology.

BACT - Best Available Control Technology. Standards for sources of regulated HAPs which relied on the most advanced control technology and incorporated economic and social issues. Developed in the 1970s and 1980s.

Bubble Program - A common name referring to the offset program as part of the nonattainment area requirements of pre - 1990 CAAA National Ambient Air Quality Standard (NAAQS) provisions. The offset program effectively created a bubble around a polluting facility for compliance purposes. For example, a facility's owner wanted to install new equipment or make modifications that would significantly increase emissions of CO in a CO nonattainment region. Then, the owner would have to reduce overall emissions of CO for the entire facility to insure no increase in CO emissions plus a specified increment to insure a net benefit to the region.

CAAA - Clean Air Act Amendments. The original air regulation, the Air Pollution Control Act was passed in 1955. Since then five amendments have been passed, the most recent was the 1990 CAAA.

CMA - Chemical Manufacturers Association.

CO - Carbon monoxide.

DEG - Diethylene glycol.

EA - Emissions averaging. A limited alternate compliance option for existing sources under the HON rule.

EG - Ethylene glycol.

EO - Ethylene oxide.

EO Pamphlet - EPA document "Locating and Estimating Air Emissions from Sources of Ethylene Oxide".

ER Rule - Early Reduction Provision of the 1990 CAAA.

EPA - United States Environmental Protection Agency.

Group 1 - Emission points with high enough concentration and/or flow rate of HAPs to be regulated under the HON rule.

Group 2 - Emission points not meeting the Group 1 criteria and therefore essentially unregulated under the HON rule.

HAP - Hazardous air pollutant. Usually refers to one or more of the 189 substances regulated under Title III of the 1990 CAAA.

HC - Hydrocarbons.

HEAST - Health Effects Assessment Summary Tables. EPA risk assessment information, published quarterly.

HI - Hazard index. Sum of all hazard quotients.

HON - Hazardous Organic National Emission Standards for Hazardous Air Pollutants. The first major Title III, 1990 CAAA regulation. Regulates industries which manufacture synthetic organic chemicals.

HQ - Noncancer hazard quotient. The ratio of a single substance exposure level over a specified time period to a reference dose for that substance derived from a similar exposure period.

HRS - Hazard Ranking System. The principle mechanism for placing sites on the National Priorities List as part of the "Superfund" program.

IRIS - Integrated Risk Information System. EPA data base with risk assessment information.

IRR - Internal Rate of Return. Calculates the discount rate that equates the present value of a project's expected cash inflows to the present value of the project's expected costs.

LC₅₀ - Lethal concentration, 50%. Concentration of a substance in air ($\mu\text{g}/\text{m}^3$) or water ($\mu\text{g}/\text{l}$) that kills 50% of a group of exposed organisms.

LD₅₀ - Lethal dose, 50%. Dose of a substance (mg/kg) that kills 50% of a group of exposed organisms.

MACT - Maximum Achievable Control Technology. Acronym for the control technology standards required on the sources of the 189 regulated HAPs under the 1990 CAAA.

MEG - Monoethylene glycol.

MES - Model Emission Source Document. EPA document "HAP Emissions from Process Units in the Synthetic Organic Chemical Manufacturing Industry--Background Information for Proposed Standards, Volume 1C: Model Emission Sources".

MPa - Megapascal.

NEPP - National Environmental Policy Plan. The Netherlands national strategy for the environment.

NESHAPs - National Emission Standards for the Hazardous Air Pollutants. The first regulation of hazardous air pollutants initiated under the 1970 CAAA.

NPR - National Performance Review.

NPV - Net present value. The sum of the project's cash flows discounted to the current year.

NRDC - Natural Resources Defense Council.

NSPS - New Source Performance Standards. Stringent requirements for new sources under Title I of the 1990 CAAA and earlier CAAA.

Parameter monitoring - A portion of the new enhanced monitoring program required as part of the 1990 CAAA Title V requirements. The program requires increased monitoring using one or a combination of the following approaches:

- * Continuous emissions monitoring systems;
- * Parametric monitoring of the process or emissions control devices;
- * Emissions calculations based on accepted engineering practices;
- * Maintenance and analysis of records of fuel or raw material usage;
- * Periodic verification of emissions or parametric monitoring systems using portable or in-situ measurement devices;
- * Development and use of specific, documented operation and maintenance procedures; or
- * Any other form of measurement that can achieve the requirements of the regulations.

Parametric or parameter monitoring requires a facility to select and monitor parameters that can be demonstrated to have a relationship to the emission rates of regulated air pollutants. For example, measured parameters may include firebox temperature, waste feed rate, combustion air flow rate, and excess oxygen. To gain approval for use, the facility must establish that a consistent relationship exists between the monitored parameter and the emission rates of the pollutants of concern.³²

PI - Profitability index. Known as the benefit/cost ratio.

PPA - Pollution Prevention Act of 1990.

ppmv - Parts per million by volume.

RCT - Reference control technology. EPA selected control technology required for compliance with the HON and other Title III regulations. These pollution control devices meet the statutory requirements for MACT and are universally applicable to the particular emission point.

RfC - Inhalation reference concentration. Defined as an estimate (with uncertainty spanning an order of magnitude or greater in some cases) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

RfD - Reference dose. Same definition as RfC.

Risk - A unitless probability an individual will develop cancer from exposure to a chemical.

SF - Slope factor. A toxicity value that defines quantitatively the relationship between dose and response.

SOCMI - Synthetic Organic Chemical Manufacturing Industry. Collective group of industries regulated under the HON rule.

SOCMA - Synthetic Organic Chemical Manufacturing Association.

STAPPA and ALAPCO - State and Territorial Air Pollution Program Administrators, and Association of Local Air Pollution Control Officials.

TCA - Total cost assessment.

TEG - Triethylene glycol.

TRE - Total resource effectiveness index. A measure of the supplemental total resource requirement per unit reduction of organic HAP associated with a process vent stream, based on vent stream flow rate, emission rate of organic HAP, net heating value, and corrosive properties. Calculated from equations in the HON rule and used to delineate Group 1 and 2 process vents.

UEF - Uncontrolled emission factor. From the EO pamphlet.

VOC - Volatile organic compound.

WRAP - Waste Reduction Always Pays. Dow Chemical Co. program that rewards employees that submit useful waste reduction, pollution prevention, and energy reduction projects.

Appendix A

A.1 Introduction

This appendix lists the tables from the Hazard Ranking System, the Early Reduction Provision, and the Control Technology Determination regulations discussed in Section 8.4.2.

A.2 Hazard Ranking System Rule

The Hazard Ranking System Rule was promulgated by the EPA in response to new statutory requirements under the Superfund Amendments and Reauthorization Act of 1986 (SARA).⁸¹ The HRS serves as a screening device to evaluate the potential for releases of uncontrolled hazardous chemicals to cause human health or environmental damage.

Part of the chemical waste evaluation is the selection of the chemical that has the potential to pose the greatest hazard. An assigned value is determined for each waste chemical at the site using one of three toxicity factor evaluation tables. The first table, for chronic toxicity (noncarcinogens), from the HRS rule, is shown in Table XXXVII. The second table, for carcinogenicity, is shown in Table XXXVIII. The third table, for acute toxicity, is shown in Table XXXIX. The source for all three tables is the Hazard Ranking Rule.⁸¹

A.3 Early Reductions Rule

The Early Reductions Rule was promulgated as the National Emission Standards for Hazardous Air Pollutants; Compliance Extensions for Early Reductions as part of the requirements of the 1990 Clean Air Act Amendments.⁷⁵ The Early Reductions Rule establishes requirements and procedures for polluting facilities (or sources) to obtain compliance extensions by significantly reducing hazardous air pollutants before the regulations requiring the pollutant

Table XXXVII. Toxicity Factor Evaluation, Chronic Toxicity

Reference Dose (RfD) (mg/kg-day)	Assigned Value
$RfD < 0.0005$	10,000
$0.0005 \leq RfD < 0.005$	1,000
$0.005 \leq RfD < 0.05$	100
$0.05 \leq RfD < 0.5$	10
$0.5 \leq RfD$	1
RfD not available	0

Table XXXVIII. Toxicity Factor Evaluation, Carcinogenicity

Weight of Evidence and Slope Factor (mg/kg-day) ⁻¹			Assigned Value
A	B	C	
$0.5 \leq SF$	$5 \leq SF$	$50 \leq SF$	10,000
$0.05 \leq SF < 0.5$	$0.5 \leq SF < 5$	$5 \leq SF < 50$	1,000
$SF < 0.05$	$0.05 \leq SF < 0.5$	$0.5 \leq SF < 5$	100
---	$SF < 0.05$	$SF < 0.5$	10
SF NA	SF NA	SF NA	0

Where: A, B, and C refer to weight of evidence categories. A chemical with a weight of evidence category of D or E should be assigned a value of 0 for carcinogenicity.

SF - slope factor

NA - not available

reductions are promulgated. The list of high-risk pollutants with the associated weighting factors are shown in Table XL. The list contains 47 chemicals from a list of 189 hazardous air pollutants required to be regulated under Title III, 1990 CAAA. The other 142 chemicals are considered lower risk and are given a weighting factor of 1. The source for the table is the Early Reduction Rule.⁷⁵

Table XXXIX. Acute Toxicity

Oral LD ₅₀ (mg/kg)	Dermal LD ₅₀ (mg/kg)	Dust or mist LC ₅₀ (mg/l)	Gas or vapor LC ₅₀ (ppm)	Assigned Value
LD ₅₀ < 5	LD ₅₀ < 2	LC ₅₀ < 0.2	LC ₅₀ < 20	1000
5 ≤ LD ₅₀ < 50	2 ≤ LD ₅₀ < 20	0.2 ≤ LC ₅₀ < 2	20 ≤ LC ₅₀ < 200	100
50 ≤ LD ₅₀ < 500	20 ≤ LD ₅₀ < 200	2 ≤ LC ₅₀ < 20	200 ≤ LC ₅₀ < 2000	10
500 ≤ LD ₅₀	200 ≤ LD ₅₀	20 ≤ LC ₅₀	2000 ≤ LC ₅₀	1
LD ₅₀ na	LD ₅₀ na	LC ₅₀ na	LC ₅₀ na	0

Where: na - not available

Table XL. List of High-Risk Pollutants

Chemical	Weighting Factor
2-Acetylaminofluorene	100
Acrolein	100
Acrylamide	10
Acrylic acid	10
Acrylonitrile	10
Arsenic compounds	100
Asbestos	100
Benzene	10
Benzidine	1000
Beryllium compounds	10
Bis(chloromethyl) ether	1000
1,3-Butadiene	10
Cadmium compounds	10
Chlordane	100
2-Chloroacetophenone	100
Chromium compounds	100
Chloromethyl methyl ether	10
Coke oven emissions	10
Diazomethane	10
Dibenzofuran	10
1,2-Dibromo-3-chloropropane	10
Dichloroethyl ether	10
Dimethylcarbamoyl chloride	100
1,2 Diphenylhydrazine	10
Ethylene dibromide	10

Table XL. List of High-Risk Pollutants (cont.)

Chemical	Weighting Factor
Ethylenimine (Aziridine)	100
Ethylene oxide	10
Heptachlor	100
Hexachlorobenzene	100
Hexachlorocyclopentadiene	10
Hydrazine	100
Manganese compounds	10
Mercury compounds	100
Methylene diphenyl diisocyanate	10
Methyl hydrazine	10
Methyl isocyanate	10
Nickel compounds	10
N-Nitrosodimethylamine	100
N-Nitroso-N-methylurea	1000
Parathion	10
Phosgene	10
Phosphine	10
Phosphorus	10
1,2-Propylenimine	100
2,3,7,8-Tetrachlorodibenzo-p-dioxin	100,000
Toxaphene (chlorinated camphene)	100
Vinyl chloride	10

A.4 Control Technology Determination

The proposed Requirements for Control Technology Determinations for Major Sources in Accordance with CAAA Sections 112(g) and 112(j) incorporates the Title III MACT standards for HAPs within the Title V Permit program. The proposed rule, which is for new facilities or major modifications to existing facilities, outlines how MACT requirements shall be incorporated

in a facility's air permit, particularly when no applicable Federal emission limitation has been promulgated. Procedures are included for evaluating whether emission offsets meet the statutory requirement of being more hazardous than emission increases being offset. The more hazardous evaluation is based on four tables listed below: Table XLI - Nonthreshold Pollutants (carcinogenic), Table XLII - Threshold Pollutants (noncarcinogenic), Table XLIII - High-Concern Pollutants, and Table XLIV - Unrankable. The source for the tables is the proposed Control Technology Determination rule.⁸³

In Table XLI, the carcinogenic pollutants are ranked by weight of evidence and an ED10 potency value. The ED10 potency value is the dose associated with a 10% increase over background in cancer incidence.⁶⁸ In Table XLII, the noncarcinogenic pollutants are ranked by a chronic toxicity scoring system developed by the EPA under the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) in establishing reportable quantities. This scoring system incorporates both the dose and severity of effect into a composite score. Table XLIII contains both carcinogenic and noncarcinogenic pollutants with are either: potent chronic toxicants, potent acute toxicants, or carcinogens with chronic toxicity outweighing that of its carcinogenicity. In Table XLIV, the unrankable pollutants have not yet been evaluated sufficiently to be ranked.

Table XLI. Nonthreshold Pollutants

CAS #	Chemical Name	WoE	1/ED ₁₀
76448	Heptachlor	B	42
119937	3,3'-Dimethyl benzidine	B	27
12035722	Nickel subsulfide	A	16
79061	Acrylamide	B	16
118741	Hexachlorobenzene	B	13
57749	Chlordane	B	11
1120714	1,3-Propane sultone	B	10
106990	1,3-Butadiene	B	8.4
-	Nickel refinery dust	A	8
53963	2-Acetylaminoflourine	B	7.7
53963	3,3'-Dichlorobenzidine	B	7.5
58899	Lindane (hexachlorcyclohexane, gamma)	B/C	7.4
95807	2,4-Toluene diamine	B	6.5
111444	Dichloroethyl ether (Bis(2-chloroethyl)ether	B	6.4
122667	1,2-Diphenylhydrazine	B	4.3
8001352	Toxaphene (chlorinated camphene)	B	4.3
121142	2,4-Dinitrotoluene	B	3.8
119904	3,3'-Dimethoxybenzidine	B	3.1
50000	Formaldehyde	B	3
101144	4,4'-Methylene bis(2-chloroaniline)	B	2.4
107131	Acrylonitrile	B	2.3
106934	Ethylene dibromide (1,2-Dibromoethane)	B	2.1
72559	DDE (1,1-p-chlorophenyl 1-2 dichloroethylene)	B	1.9
510156	Chlorobenzilate	B	1.8
62737	Dichlorvos	B	1.7

Table XLI. Nonthreshold Pollutants, cont.

CAS #	Chemical Name	WoE	1/ED ₁₀
92671	4-Aminobiphenyl	1, IARC	**
96093	Styrene oxide	2A, IARC	**
64675	Diethyl sulfate	2A, IARC	**
59892	N-Nitrosomorpholine	2B, IARC	**
68122	Dimethyl formamide	2B, IARC	**
680319	Hexamethylphosphoramide	2B, IARC	**
60355	Acetamide	2B, IARC	**
101779	4,4'-Methylenedianiline	2B, IARC	**
90040	o-Anisidine	2B, IARC	**
1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin	B	660000
-	Beryllium salts	B	18000
92875	Benzidine	A	2200
684935	N-Nitroso-N-methylurea	B	2100
542881	Bis(chloromethyl)ether	A	1400
79447	Dimethyl carbamoyl chloride	B	500
-	Chromium compounds (hexavalent)	A	390
75558	1,2-Propylenimine (2-Methyl aziridine)	B	150
99999904	Arsenic and inorganic arsenic compounds ***	A	140
302012	Hydrazine	B	110
57147	1,1-Dimethyl hydrazine	B	83
7440417	Beryllium compounds ****	B	80
62759	N-Nitrosodimethylamine	B	61
-	Cadmium compounds	B	58
50328	Benzo (a) pyrene	B	54
1336363	Polychlorinated biphenyls (Aroclors)	B	50

Table XLI. Nonthreshold Pollutants, cont.

CAS #	Chemical Name	WoE	1/ED ₁₀
75014	Vinyl chloride	A	1.6
99999908	Coke oven emissions	A	1.5
75218	Ethylene oxide	B	1.3
96457	Ethylene thiourea	B	0.98
593602	Vinyl bromide (bromoethene)	B	0.93
7488564	Selenium sulfide (mono and di)	B	0.93
67663	Chloroform	B	0.76
87865	Pentachlorophenol	B	0.67
51796	Ethyl carbamate (Urethane)	B	0.64
107062	Ethylene dichloride (1,2-Dichloroethane)	B	0.39
78875	Propylene dichloride (1,2-Dichloropropane)	B	0.36
56235	Carbon tetrachloride	B	0.34
71432	Benzene	A	0.27
60344	Methyl hydrazine	B	0.25
140885	Ethyl acrylate	B	0.22
75569	Propylene oxide	B	0.16
62533	Aniline	B	0.13
106467	1,4-Dichlorobenzene (p)	B	0.13
88062	2,4,6-Trichlorophenol	B	0.09
117817	Bis(2-ethylhexyl)phthalate (DEHP)	B	0.086
95534	o-Toluidine	B	0.093
114261	Propoxur	B	0.053
79016	Trichloroethylene	B/C	0.035
123911	1,4-Dioxane (1,4-Diethyleneoxide)	B	0.034
75070	Acetaldehyde	B	0.033

Table XLI. Nonthreshold Pollutants, cont.

CAS #	Chemical Name	WoE	1/ED ₁₀
75252	Bromoform	B	0.029
133062	Captan	B	0.026
106898	Epichlorohydrin	B	0.021
75092	Methylene chloride (Dichloromethane)	B	0.013
127184	Tetrachloroethylene (Perchloroethylene)	B/C	0.012
53703	Dibenz (ah) anthracene	B	-
218019	Chrysene	B	-
60117	Dimethyl aminoazobenzene	B	-
56553	Benzo (a) anthracene	B	-
205992	Benzo (b) fluoranthene	B	-
1309644	Antimony trioxide	B	-
79469	2-Nitropropane	B	-
542756	1,3-Dichloropropene	B	-
557976	7,12-Dimethylbenz(a)anthracene	B	-
225514	Benz(c)acridine	B	-
193395	Indeno(1,2,3-cd)pyrene	B	-
189559	1,2:7,8-Dibenzopyrene	B	-
79345	1,1,2,2-Tetrachloroethane	C	1.7
91225	Quinoline	C	1.4
75354	Vinylidene chloride (1,1-Dichloroethylene)	C	1.2
87683	Hexachlorobutadiene	C	0.36
82688	Pentachloronitrobenzene (Quintobenzene)	C	0.25
78591	Isophorone	C	0.016
79005	1,1,2-Trichloroethane	C	0.21
74873	Methyl chloride (Chloromethane)	C	0.052

Table XLI. Nonthreshold Pollutants, cont.

CAS #	Chemical Name	WoE	1/ED ₁₀
67721	Hexachloroethane	C	0.051
1582098	Trifluralin	C	0.037
*****	Nickel compounds	see footnote	-
1319773	Cresols/Cresylic acid (isomers and mixture)	C	-
108394	m-Cresol	C	-
75343	Ethylidene dichloride (1,1-Dichloroethane)	C	-
95487	o-Cresol	C	-
106445	p-Cresol	C	-
74884	Methyl iodide (Iodomethane)	C	-
100425	Styrene *****	see footnote	-
107051	Allyl chloride	C	-
334883	Diazomethane	*	-
95954	2,4,5-Trichlorophenol	*	-
133904	Chloramben	*	-
106887	1,2-Epoxybutane	*	-
108054	Vinyl acetate	*	-
126998	Chloroprene	*	-
123319	Hydroquinone	*	-
92933	4-Nitrobiphenyl	*	-

Where: 1, 2A, or 2B IARC =

* =

** =

*** =

**** =

***** =

***** =

¹/ED₁₀ -

IARC classification for carcinogenicity (sufficient human or animal evidence exists to be placed in the "non-threshold" category)

Currently an EPA weight of evidence classification is under review

An EPA weight of evidence classification and possible ED₁₀ are under development

Except arsenic pentoxide, arsenous oxide, and arsine

Except beryllium salts

Except subsulfide, carbonyl, and refinery dust, nickel and nickel salts are treated similarly to CERCLA section 101 and treated like compounds having a weight of evidence of Group C. The IARC has given Nickel as a class a weight of evidence of Group 1 or "carcinogenic to humans."

The EPA does not currently have an official weight-of-evidence classification for styrene. For purposes of this rule, styrene is treated as a "non-threshold" pollutant. (See data report form in appendix A of the hazard ranking technical background document.)

per (mg/kg/day)

Table XLII. Threshold Pollutants

CAS #	Chemical Name	Composite Score
75058	Acetonitrile	20
94757	2,4-D, salts and esters	18
156627	Calcium cyanamide	16
110805	2-Ethoxy ethanol	15
121448	Triethylamine	14
110543	Hexane	13
91203	Naphthalene	11
7647010	Hydrochloric acid	11
98828	Cumene	11
111762	Ethylene glycol monobutyl ether	11
79107	Acrylic acid	10
107211	Ethylene glycol	10
63252	Carbaryl	10
92524	Biphenyl	10
78933	Methyl ethyl ketone (2-Butanone)	10
84742	Dibutylphthalate	9
105602	Caprolactam	9
100414	Ethyl benzene	9
106423	p-Xylenes	8
95476	o-Xylenes	8
1330207	Xylenes (isomers and mixture)	8
72435	Methoxychlor	8
108383	m-Xylenes	8
67561	Methanol	7
131113	Dimethyl phthalate	7
108883	Toluene	7

Table XLII. Threshold Pollutants, cont.

CAS #	Chemical Name	Composite Score
1634044	Methyl tert-butyl ether	6
80626	Methyl methacrylate	5
108101	Methyl isobutyl ketone	4
120821	1,2,4-Trichlorobenzene	4
75003	Ethyl chloride	4
106503	p-Phenylenediamine	4
108907	Chlorobenzene	3
71556	Methyl chloroform (1,1,1-Trichloroethane)	2

Table XLIII. High-Concern Pollutants

CAS #	Chemical Name	Composite Score
-	Lead and lead compounds	C*
56382	Parathion	A*
13463393	Nickel Carbonyl	A*
60344	Methyl hydrazine	A*
75218	Ethylene oxide	A*
151564	Ethylene imine	A*
77781	Dimethyl sulfate	A*
107302	Chloromethyl methyl ether	A*
57578	beta-Propiolactone	A*
100447	Benzyl chloride	A*
98077	Benzotrichloride	A*
107028	Acrolein	A*
584849	2,4 - Toluene diisocyanate	A*
7784421	Arsine	A
7550450	Titanium tetrachloride	A
75741	Tetramethyl lead	A
78002	Tetraethyl lead	A
10102188	Sodium selenite	A
13410010	Sodium selenate	A
143339	Sodium Cyanide	A
151508	Potassium cyanide	A
7723140	Phosphorous	A
75445	Phosgene	A
12108133	Methylcyclopentadienyl manganese	A
624839	Methyl isocyanate	A

Table XLIII. High-Concern Pollutants, cont.

CAS #	Chemical Name	Composite Score
7783075	Hydrogen selenide	A
7664393	Hydrogen fluoride	A
77474	Hexachlorocyclopentadiene	A
62207765	Fluomine	A
10210681	Cobalt carbonyl	A
10025737	Chromic chloride	A
79118	Chloroacetic acid	A
7782505	Chlorine	A
1306190	Cadmium oxide	A
1327533	Arsenous oxide	A
1303282	Arsenic pentoxide	A
7783702	Antimony pentafluoride	A
534521	4,6-Dinitro-o-cresol and salts	A
101688	Methylene diphenyl diisocyanate	46
7440484	Cobalt and compounds	46
1345046	Antimony trisulfide	46
108952	Phenol	44
7782492	Selenium and compounds **	42
10045940	Mercuric nitrate	42
743996	Manganese and compounds ***	41
748794	Mercuric chloride	40
28300745	Antimony potassium tartrate	38
62384	Mercury, (acetato-o) phenyl	37
98862	Acetophenone	37
108316	Maleic anhydride	35

Table XLIII. High-Concern Pollutants, cont.

CAS #	Chemical Name	Composite Score
532274	2-Chloroacetophenone	32
51285	2,4-Dinitrophenol	30
108864	2 Methoxy ethanol	24
98953	Nitrobenzene	23
74839	Methyl bromide (Bromomethane)	23
75150	Carbon disulfide	23
121697	N,N-Dimethylaniline	21

Where: A = On the list because of severe acute toxicity
 * = Also elicits carcinogenic effects
 ** = Except hydrogen selenide, selenium sulfide, selenium disulfide, sodium selenate, and sodium selenite
 *** = Except methycyclopentadienyl manganese
 C = Of concern for chronic noncarcinogenic effects which have been demonstrated at current exposure levels

Table XLIV. Unrankable Pollutants

CAS #	Chemical Name	IARC
106514	Quinone	III
123386	Propionaldehyde	
120809	Catechol	III
85449	Phthalic anhydride	
463581	Carbonyl sulfide	
132649	Dibenzofurans	
100027	4 - Nitrophenol	
540841	2,2,4 - Trimethylpentane	
11422	Diethanolamine	
822060	Hexamethylene,-1, 6 -diisocyanate	
1332214	Asbestos	
7803512	Phosphine	
-	Radionuclides	
-	Mineral fibers @	
-	Antimony compounds *	
-	Cyanide compounds **	
-	Glycol ethers ***	
-	Mercury compounds ****	
-	Polycyclic organic matter *****	
-	Trivalent chromium compounds *****	

Where: * = Except for antimony trioxide, antimony trisulfide, antimony potassium tartrate, and antimony pentafluoride

** = Except for sodium cyanide and potassium cyanide

*** = Except for 2-ethoxy ethanol, ethylene glycol monobutyl ether, and 2-methoxy ethanol

**** = Except for mercuric nitrate, mercuric chloride, mercury (acetato-o) phenyl, and ethyl mercuric phosphate

***** = Except for benzo(b)fluoranthene, benzo(a)anthracene, benzo(a)pyrene, 7,12-dimethylbenz(a)anthracene, benz(c)acridine, chrysene, dibenz(ah) anthracene, 1,2:7,8-dibenzopyrene, indeno(1,2,3-cd)pyrene, but including dioxins and furans

***** = Awaiting a determination by the Agency (except for chromic chloride)

@ = Including crystalline silica, erionite, talc containing asbestos form fibers, glass wool, rock wool, slag wool, and ceramic fibers.

Appendix B

This Appendix provides conversion factors for Chapter 11.

Table XLV. Conversion Factors

To Convert From	To	Multiply By
mm Hg	psi	0.0193368
Pa (N/m ²)	psi	1.4504×10^{-4}
psi	Pa	6.8948×10^3
F°	°C	$0.555(F° - 32)$
ton	kg	907.2
lb	kg	0.4536
gal	m ³	3.7854×10^{-3}
gal	l	3.7854

Table XLVI. Metric Standard Prefixes

Factor	Symbol	Prefix
10^{-3}	m	milli
10^3	k	kilo
10^6	M	mega

Appendix C

This Appendix documents the determination of the values in Table XXIII in Section 11.3 RCT Implementation Plan. Table XXIII is shown again below. Six rows are listed in the table, two from the Plaquemine Glycol II plant and the other four from the MES Document.^{88,95} The last row is an average of the two rows above.

Table XXIII. Process Vents Group 1 - 2 Delineation

Process Vent	Data Source	Flow Rate m ³ /min	HAP Conc. ppmv	TRE Value	Group
EO Vent A Main Process	Glycol II	2.3×10^3	0.56	3.9	2
	MES Document	2.4×10^3	2.6	29	2
EG Combined Vent	Glycol II	1.9×10^4	0.10	14	2
	MES Document Evaporator	1.3	2.0×10^5	8.5×10^{-2}	1
	MES Document Distillation	1.6	4.7×10^4	1.1	1 or 2
	Average of MES	1.5	1.2×10^5	0.59	1

The flow rate values for the two Glycol II vents came from the plant 1986 Emission Inventory Questionnaire and the MES Document values shown in Table XXI. The values from the MES Document were adjusted to account for the production rate of the Glycol II plant using Equation 23. The EO/EG production rate was 2.0×10^8 kg/yr for EO and 1.8×10^8 kg/yr for EG. The production rate from the MES Documents was shown in Table XXI under production capacity.

$$Q_A = \left(\frac{P_{EO/EG}}{P_{MES}} \right) \times Q_{MES} \quad \text{Equation 23}$$

Where:

Q_A	-	Adjusted flow rate, m ³ /min
$Q_{EO/EG}$	-	EO or EG production rate of baseline facility, 2.0×10^8 kg/yr or 1.8×10^8 kg/yr, respectively
P_{MES}	-	Production rate from MES document, kg/yr
Q_{MES}	-	Flow rate from MES document, m ³ /min

For the MES Document entries, the HAP concentration values were calculated using Equation 24. The HAP composition weight % is given in the MES Document. The molecular weight ratios are used because at given conditions the molecular weight of a substance occupies the same volume as any other substance. It was assumed the only pollutant was either EO or EG depending on the vent and the rest of the vent stream was air. The $\times 10^4$ converts to ppm.

$$HAP \text{ Conc} = HAP \text{ Wt\%} \times \left(\frac{MW_A}{MW_{HAP}} \right) \times 10^4 \quad \text{Equation 24}$$

Where:

$HAP \text{ Conc}$	-	HAP Concentration, ppmv
$HAP \text{ Wt\%}$	-	HAP composition weight %
MW_A	-	Molecular weight of air
MW_{HAP}	-	Molecular weight of HAP

Calculating the HAP concentration using the Glycol II data required a similar approach, see Equation 25.⁹⁶ The Glycol II plant Emission Inventory Questionnaires listed the HC emission rate, in lb/hr, and the total emission rate from the vent in ft³/hr. The HC was assumed to be either EO or EG and the remaining vent stream air.

$$HAP \text{ Conc} = \frac{ER}{(MW_{HAP} \times Q)} \times \frac{hr}{60 \text{ min}} \times \frac{359 \text{ ft}^3 \text{ HAP}}{\text{mole HAP}} \times \frac{(460+t)}{460} \times 10^6$$

Equation 25

Where:

ER	-	HAP emission rate, lb/hr
Q	-	Vent flow rate, ft ³ /hr
t	-	Exit temperature, °F

Four values; the HAP hourly emission rate, E_{HAP} , the vent stream flow rate, Q_s , the vent stream net heating value, H_T , and the emission rate of total organic carbon, E_{TOC} , were needed to calculate the TRE values. These values are shown in Table XLVII.

Table XLVII. Determining TRE Values

Process Vent	E_{HAP} kg/hr	Q_s m ³ /min	H_T^1 MJ/m ³	E_{TOC} kg/hr	TRE Value		
					Fl ²	TI ₀ ³	TI ₇₀ ⁴
EO Vent A Glycol II	4.3	1.2×10^3	1.0	4.3	100	18	<u>3.9</u>
EO Vent A MES Vent #1	2.4	1.7×10^3	0.22	1.0×10^3	260	45	<u>29</u>
EG Vent Glycol II	16	1.9×10^4	0.3	16	430	75	<u>14</u>
EG Vent MES Vent #3	25	1.2	28	34	<u>0.085</u>	0.097	0.18
EG Vent MES Vent #5	1.6	1.5	4.5	3.2	1.5	<u>1.1</u>	17

Where: ¹MJ - Megajoules
²Fl - Flare calculation
³TI₀ - Thermal incinerator with 0% heat recovery
⁴TI₇₀ - Thermal incinerator with 70%

The EO Vent A Glycol II was the expander vent and the EG Vent Glycol II was the cooling tower. The other three process vents are from data in the MES Document and the vent number corresponds to the emission source number in Table XXI. Vent #1 is the Air Oxidation Vent #1 in Table XXI, Vent #3 is an average of Distill Vent #2NV and #3NV, and Vent #5 is Distill Vent #2V. E_{HAP} was assumed to be the HC emission levels reported in the Emission Inventory Questionnaires for the Glycol II process vents. Values were converted from lb/hr to kg/hr. The E_{HAP} values from the MES Document vents were converted from the HAP emission rate, kg/yr, in Table XXI, to kg/hr.

The Q_s is the flow rate, determined earlier, adjusted for temperature to 20°C using Equation 26. H_T values were reported in the MES Document. Values for the Glycol II vents were estimated by comparing the H_T values given for the various HAP concentration levels in the MES Document and selecting a close value. E_{TOC} is assumed equal to E_{HAP} for the Glycol II process vents because no other information is available. The E_{TOC} value for the MES Document vents came from the total VOC emission rate value shown in Table XXI. VOC was assumed to be TOC and the values were corrected for production size and units.

$$Q_c = Q \times \frac{(273 + 20^\circ)}{(273 + T^\circ)} \quad \text{Equation 26}$$

Where:

Q_c	-	Flow rate corrected temperature to 20° C
Q	-	Flow rate at T temperature
T	-	Original temperature of flow, °C

The HON rule requires the TRE value to be calculated three times using different coefficients listed in Table I of the HON rule.²⁹ The TRE values listed in Table XLVII were calculated for a flare, a thermal incinerator with 0% heat recovery, and a thermal incinerator with 70% heat recovery, respectively. The lowest TRE value, underlined in Table XLVII, must be used and is the value shown in Table XXIII.

Appendix D

This Appendix includes the data from the spreadsheets used to complete the Total Cost Assessment comparing costs of implementing the ACS and RCT compliance programs at the example facility (Section 12.3).

The sources for the cost data were identified in Section 12.3. A time horizon of ten years was used. Double-declining depreciation allowance was used and an inflation or escalation rate of 5% was assumed. Revenues were assumed to be \$20,000,000 for the baseline facility and the income tax rate was assumed to be 34%.

The operating costs and return on investment for the RCT compliance program are shown in Table XLVIII and XLIX, respectively. Table L displays the long-term financial indicators for the RCT program. The net present value (NPV) and the profitability indicator (PI) were calculated using a 8%, 10%, 12%, and 15% cost of capital interest rate. Only one value is shown for the internal rate of return (IRR) because it is essentially a cost of capital.

The operating costs (savings) and return on investment for the ACS compliance program are shown in Table LI and LII, respectively. Table LIII displays the long-term financial indicators for the ACS program. The values in the six tables are from a Quatro Pro spreadsheet. Some round-off error may have occurred in transferring tables but the values in Tables L and LIII are accurate.

NPV was calculated using Equation 27. PI is the present value of the benefits divided by the initial capital cost. The present value of the benefits was calculated using Equation 28. IRR is the *Rate* for which the NPV is equal to zero and is also calculated using Equation 27.

$$NPV = \sum_{t=1}^n \frac{v_t}{(1 + Rate)^t} \quad \text{Equation 27}$$

Where:

v_t	-	Cash flow values
$Rate$	-	Fixed periodic interest rate, the cost of capital
t	-	Number of time periods, 1...n

$$PV = Pmt \times \left(\frac{1 - (1 + Rate)^{-Nper}}{Rate} \right) \quad \text{Equation 28}$$

Where:

PV	-	Present value
Pmt	-	Numeric value representing the amount of the periodic payment. A value of \$11,915 was used for the RCT program and \$13,936 for the ACS program.
$Nper$	-	Number of periods. 10 was used.

Table XLVIII. Operating Costs - RCT Compliance Method

Annual Costs & Savings	Operating Yr \$(000)									
	1	2	3	4	5	6	7	8	9	10
Flare	-1800	-1890	-1985	-2084	-2188	-2297	-2412	-2533	-2659	-2792
Tank roof	5	5	6	6	6	6	7	7	7	8
Vapor collection system	-15	-16	-17	-17	-18	-19	-20	-21	-22	-23
Overhead	-270	-284	-298	-313	-328	-345	-362	-380	-399	-419
Total	-2080	-2184	-2293	-2408	-2528	-2655	-2787	-2927	-3073	-3227

Table XLIX. Return on Investment - RCT Compliance Method

Return on Investment	Operating Yr \$(00,000)									
	1	2	3	4	5	6	7	8	9	10
Capital value ¹	10	8.3	6.7	5.3	4.3	3.4	2.7	2.2	1.8	1.4
Depreciation	2.6	2.0	1.7	1.3	1.1	0.85	0.68	0.55	0.44	0.35
Cash Flows										
Revenues	200	210	221	232	243	255	268	281	295	310
Op. costs ²	-21	-22	-23	-24	-25	-27	-28	-29	-31	-32
Net revenues	179	188	198	207	218	229	240	252	265	278
Depreciation	-2.6	-2.0	-1.7	-1.3	-1.1	-0.85	-0.68	-0.55	-0.44	-0.35
Taxable income	177	186	196	206	217	228	239	252	264	278
Income tax	-60	-63	-67	-70	-74	-78	-81	-86	-90	-94
Profit after tax	117	123	129	136	143	150	158	166	174	183
Depreciation	2.6	2.0	1.7	1.3	1.1	0.85	0.68	0.55	0.44	0.35
Cash Flow ³	119	125	131	137	144	151	159	167	175	184

Where:

1

-

Initial capital value is \$1300,000 in the year before the first operating cost year.

2

-

Operating costs from Table XLVI.

3

-

The initial cash flow is -\$1300,000 capital investment in the year preceding the first operating cost year.

Table L. Long-term Financial Indicators - RCT Compliance Method

Indicator	Cost of Capital			
	8 %	10 %	12 %	15 %
NPV (000)	\$88,693	\$79,068	\$70,815	\$60,519
PI	61	56	52	46
IRR	9.2			

Table LI. Operating Costs - ACS Compliance Method

Annual Costs & Savings	Operating Yr \$(000)									
	1	2	3	4	5	6	7	8	9	10
Mod cooling tower	-280	-294	-309	-324	-340	-357	-375	-394	-414	-434
Change EO process	1300	1365	1433	1505	1580	1659	1742	1829	1921	2016
Tank modif	250	263	276	289	304	319	335	352	369	388
Vapor collection system	-9	-9.5	-9.9	-10.4	-10.9	-11.5	-12.1	-12.7	-13.3	-14.0
WWTP savings	120	126	132	139	146	153	161	169	177	186
Overhead	-543	-570	-599	-629	-660	-693	-728	-764	-802	-842
Total	838	880	924	970	1019	1070	1123	1179	1238	1300

Table LII. Return on Investment - ACS Compliance Method

Return on Investment	Operating Yr \$(00,000)									
	1	2	3	4	5	6	7	8	9	10
Capital value ¹	22	17	14	11	8.8	7.1	5.7	4.5	3.6	2.9
Depreciation	5.4	4.3	3.5	2.8	2.2	1.8	1.4	1.1	0.91	0.72
Cash Flows										
Revenues	200	210	221	232	243	255	268	281	295	310
Op. savings ²	8.4	8.8	9.2	9.7	10	11	11	12	12	13
Net revenues	208	219	230	241	253	266	279	293	308	323
Depreciation	-5.4	-4.3	-3.5	-2.8	-2.2	-1.8	-1.4	-1.1	-0.91	-0.72
Taxable income	203	214	226	238	251	264	278	292	307	323
Income tax	-69	-73	-77	-81	-85	-90	-94	-99	-104	-110
Profit after tax	134	142	149	157	166	174	183	193	203	213
Depreciation	5.4	4.3	3.5	2.8	2.2	1.8	1.4	1.1	0.91	0.72
Cash Flow ³	139	146	153	160	168	176	185	194	204	214

Where: ¹ - Initial capital value is \$2700,000 in the year before the first operating cost year.
² - Operating costs from Table XLIX.
³ - The initial cash flow is -\$2700,000 capital investment in the year preceding the first operating cost year.

Table LIII. Long-term Financial Indicators - ACS Compliance Method

Indicator	Cost of Capital			
	8%	10%	12%	15%
NPV (000)	\$102,289	\$91,097	\$81,504	\$69,536
PI	35	32	29	26
IRR	5.2			